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Index of Central Obesity as a Parameter to Evaluate Metabolic Syndrome for White, Black, and Hispanic Adults in the United States

Rebecca Lynn Griesemer

INDEX OF CENTRAL OBESITY AS A PARAMETER TO EVALUATE METABOLIC SYNDROME FOR WHITE, BLACK, AND HISPANIC ADULTS IN THE UNITED STATES

by

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TO EVALUATE METABOLIC SYNDROME FOR
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ABSTRACT

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Index Of Central Obesity As A Parameter To Evaluate Metabolic Syndrome For White, Black, And Hispanic Adults In The United States

Metabolic syndrome is a cluster of disorders including central obesity, hypertension, dyslipidemia, and hyperglycemia. Today's metabolic syndrome definitions identify central obesity by waist circumference (WC) measurements. A recent pilot study suggests that cut-points derived from a waist-to-height ratio (WHtR), or Index of Central Obesity (ICO), is a more accurate measurement of central obesity. This study compared the association between the metabolic syndrome components and central obese parameters (ICO and WC) among the white, black, and Hispanic adults in the United States. The subjects' data was obtained from the 2005-2006 National Health and Nutrition Examination Survey. ICO was highly correlated with metabolic syndrome components among white subjects and the least correlated in Hispanic subjects. Multivariate logistic regression analysis did not indicate that ICO was a better parameter for metabolic syndrome than WC. Other WHtR cut-points may be more sensitive in predicting metabolic syndrome components than the values used in this study.

INDEX WORDS: metabolic syndrome, central obesity, Index of Central Obesity, waist-to-height ratio, waist circumference, hypertension, dyslipidemia, hyperglycemia, diabetes, cardiovascular disease

AUTHOR'S STATEMENT PAGE

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CHAPTER I
INTRODUCTION

The association between certain metabolic disorders and cardiovascular disease was first recognized in the 1940's.[1] Professor Jean Vague proposed that upper body obesity was better correlated with diabetes and cardiovascular disease than excess body weight.[2, 3] Vague used the terms "android adiposity" to describe the accumulation of fat around the abdomen and "gynoid adiposity" to describe the accumulation of fat found in the hips and thigh region.[3] Vague studied the differences between the body fat topographies and concluded that the obese gynoid phenotype was associated with "mechanical complications" and the android phenotype was associated with metabolic disturbances.

During the 1960's, other researchers observed a relationship between obesity and various metabolic related disorders.[4] Dr. Reaven, in 1988, first described the cluster of metabolic disorders related to insulin resistance.[5, 6] Reaven referred to this constellation of disorders as "Syndrome X". Insulin resistance was the common denominator, according to Reaven, and was associated with a hypertriglyceridemia, a decrease in high density lipoprotein (HDL), and hypertension. However, Reaven omitted obesity as a component of Syndrome X since he argued that insulin resistance could be found in non-obese individuals.[5]

With the advancement of imaging techniques such as computer tomography (CT), researchers were able to accurately distinguish between distributions of fat and showed an association between central obesity and metabolic disorders.[7, 8] This new

technology demonstrated how individuals with "normal" weight could have an unhealthy accumulation of abdominal fat and develop metabolic risk factors, thus corroborating Reaven's finding of insulin resistance in persons with normal weight, but centrally obesity. Since Reaven's "Syndrome X", the constellation of diabetes and cardiovascular risk factors has been changed to "metabolic syndrome", with central obesity as a required variable of the syndrome.[9-11]

Although the physiopathological mechanism by which central obesity fosters metabolic syndrome is debatable, some theories have been widely accepted.[12] Visceral fat in the truncal region is of particular importance. Compared to subcutaneous fat, visceral fat has a higher rate of lipolysis with release of free fatty acids (FFA).[12-14] Elevated levels of FFAs are known to impair insulin function and glucose uptake. FFAs mobilized from visceral fat pass directly to the liver via the portal vein, leading to hyperglycemia, hepatic insulin resistance, and dyslipidemia, hyperinsulinemia , and decreased skeletal muscle insulin sensitivity.[13] In contrast, the subcutaneous fat found in the femoral-gluteal region plays a less active role in lipolysis and FFA circulation and may be a protective factor for metabolic disorders.[14] The subcutaneous fat depot acts as a "safe haven for the sequestration of excess calories"[14] and prevents FFA circulation and fat storage in the liver, skeletal muscle and pancreas.[15, 16]

Currently, most health professionals agree that five components define the metabolic syndrome: obesity, elevated triglycerides, reduced HDL, elevated blood glucose, and hypertension.[17 18, 19] However, the clinical parameters used to identify metabolic syndrome vary among experts. For example, in 1998 the World Health Organization (WHO) proposed that the metabolic syndrome criteria require clinical

evidence of insulin resistance plus two of the following: (1) obese waist-to-hip ratio or BMI >30 kg/m^2, (2) raised triglycerides, (3) reduced HDL, (4) raised blood pressure, and (5) microalbuminuria. [11, 17]

In 2001, The National Cholesterol Education Program – Adult Treatment Panel (NCEP-ATPIII) developed less stringent criteria and categorized metabolic syndrome as having any of the following three: (1) obese waist circumference, (2) raised triglycerides, (3) reduced HDL, (4) raised blood pressure, and (5) raised fasting blood glucose.[18] Concurrently, the International Diabetes Federation (IDF) developed a metabolic syndrome definition similar to ATPIII, with greater emphasis on central obesity. The IDF criterion requires a diagnosis of waist circumference obesity in addition to the presence of any two of the following: (1) raised triglycerides, (2) reduced HDL, (3) raised blood pressure, and (4) raised fasting blood glucose. [19] In addition, the IDF recommends using ethnic-specific obese waist circumference cut-points based on previous research and other data sources.

Using the diagnostic guidelines, approximately 25% of adults in the United State have been found to have metabolic syndrome--approximately 47 million American men and women. [20, 21] Those with metabolic syndrome are at a 2-fold increased risk for cardiovascular disease (CVD) and a 4-fold increase risk for diabetes.[21-23] The metabolic syndrome thus amplifies the public health significance of diabetes, which already affects nearly 20.6 million U.S adults, 20 years of age and older.[24] The American Diabetes Association estimates that the 2007 medical expenditures and indirect costs for diabetes were $174 billion.

In subjects with diabetes, 65% have been found to have CVD,[25] also a major health burden in the United states. An estimated 80.7 million people in the United States had CVD in 2005 and over 860,000 deaths occurred in the prior year.[26] CVD is the leading cause of death for white, black, and Hispanic American adults, according the American Heart Association (AHA). AHA projects the 2008 direct and indirect costs of managing patients with CVD will be $448.5 billion. Thus, diabetes, CVD and metabolic syndrome are overlapping conditions that contribute significantly to morbidity and mortality in the U.S.

Measuring central obesity is a key factor in the diagnosis and surveillance of metabolic syndrome. Various techniques such as hydrodensitometry weighing, skinfold measurements, dual energy X-ray absorptiometry (DEXA), magnetic resonance imaging (MRI), and CT, have been used to measure obesity, but are not necessarily appropriate for population-based screening of central obesity.[27-30] The cost, discomfort, and risk of these methods can be prohibitive, or at a minimum, variable and operator-dependent. Anthropometric indices, such as BMI, waist circumference (WC), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR),[31, 32] are easier to conduct and can be used as surrogate measurements for visceral adiposity.[30, 33]

Although anthropometric indices of BMI, WC, WHR, and WHtR are currently accepted measurements of obesity, experts are not in accord with which obesity indicator is the best predictor for metabolic risk factors.[17-19, 31] As previously stated, WHO uses WHR and both NCEP-ATPIII and IDF use WC as parameters of central obesity. WHO and IDF use BMI as an alternate obesity index when WC is not obtainable. Although,

WHtR is not currently used as a criterion for metabolic syndrome, recent studies suggest that WHtR may be a better parameter of central obesity.[34-36]

To illustrate the WHtR, a 2006 pilot study using the IDF guidelines compared two males with identical WC and BMI measurements but of different heights.[37] Their glucose test results were considerably different, which the authors inferred could be related to a difference in their heights. As part of their study, the researchers created a new measurement called the Index of Central Obesity (ICO). They defined ICO as an obese WHtR cutoff value derived from dividing the national average height by IDF's ethnic and gender-specific obese waist circumference values. The researchers demonstrated that adiposity distribution may be more accurately measured with height as part of the equation. The authors suggest that ICO may be a better measure of central obesity than WC because it encompasses the variation of different statures.

To our knowledge, no studies have been conducted using specific WHtR cutoff values to evaluate metabolic syndrome in the adult population in the United States. This study hypothesizes that the novel parameter, ICO, may be better associated with metabolic syndrome components in the white, black, and Hispanic adults in the United States compared to WC, regardless of age or gender. This study will examine the relationships between ICO and factors related to metabolic syndrome using adults 20 years of age and older from a large nationwide, population-based survey.

CHAPTER II

LITERATURE REVIEW

The aim of this study is to determine if ICO is a better index of central obesity for the diagnosis of metabolic syndrome as compared to the current WC. The discussion and evaluation of any relationship between ICO and metabolic syndrome components would be premature without a comprehensive literature review of the current guidelines and central obesity indices. The literature review will include: (1) an overview of the current guidelines for metabolic syndrome diagnosis and their rationale, (2) a review of studies analyzing the most common central obesity parameters (BMI, WHR, WC, and WHtR), and (3) a summary of the pilot study and their novel parameter, ICO.

2.1 Guidelines for Metabolic Syndrome

Attempts to create a unified definition of metabolic syndrome have been made by various expert groups.[33, 38] The first attempt began in 1998 as WHO responded to the epidemic of obesity, diabetes, and cardiovascular disease and developed a preliminary set of guidelines to assist in the diagnosis of metabolic syndrome (Table 1).[33, 39] However, some experts disagree on components of the criteria. First, measuring insulin resistance requires specific laboratory techniques to determine if the individual is in the lowest quartile of insulin sensitivity which may be unrealistic in certain settings.[33] Second, the criterion for high blood pressure is ambiguous. It is uncertain if the parameter for hypertension diagnosis is ≥130mmHg systolic *and* ≥85mmHg diastolic or if it is

≥130mmHg systolic *or* ≥85mmHg diastolic.[38] Third, WHO designated WHR as a parameter of central obesity which some argue is not be the best indicator of abdominal adiposity.[40]

In 1999, the European Group for the Study of Insulin Resistance (EGIR) developed a definition of metabolic syndrome to be used in non-diabetic subjects only,[38] followed by the NCEP ATPIII's less fastidious definition, which allows for a simple application in clinical and epidemiological settings (Table 1).[18, 38] The NCEP ATPIII definition received criticism for their vague hypertension parameters, similar to WHO's parameters.[38] Furthermore, the WC values are gender-specific but do not factor racial/ethnic differences despite earlier studies demonstrating racial/ethnic disparities in anthropometric measurements and adiposity distribution.[41-49] For example, Zhu et al. found that BMI levels corresponded to a 5 to 6 centimeter larger WC in white males compared to black males, with Hispanic males in between.[41] Other studies have supporting evidence that blacks tend to have lower volumes of visceral adiposity and higher volumes of subcutaneous fat at any given obesity indices compare to their white counterparts.[43-49]

For the above reason, IDF developed a new definition for metabolic syndrome that was very similar to NCEP ATPIII, but stratified WC cut-points by ethnicity (Table 1). IDF's objective was to create one definition as a diagnostic tool applicable worldwide for identifying patients at elevated risk of CVD or Type 2 diabetes.[19, 33] Creating a universal definition would also allow comparisons of metabolic syndrome prevalence and surveillance across all populations. What distinguishes IDF's definition of metabolic syndrome from NCEP ATPIII's is the requirement of a central obesity based on ethnic-

specific WC cut-off values.[18, 33] The IDF's rationale for ethnic-specific WC cut-points is based on the findings from previous cross-sectional studies identifying individuals with elevated adiposity and elevated risk for CVD at a BMI ≥25 kg/m^2 or WHR ≥0.90.[33] The IDF recommends ethnic-specific WC cut-points should be used irrespective of the individual's place of residence. However, the IDF recognizes that United States residents will likely continue to be screened according to the NCED ATPIII WC cut-points: 102cm for male and 88cm for female.

Table 1. Definitions of Metabolic Syndrome

	National Cholesterol Education Program Adult Treatment Panel III	International Diabetes Federation	World Health Organization
Criteria	≥ 3 components	Central obesity + ≥ 2 components	Insulin Resistance* + ≥ 2 components
Obesity	WC >40" (men) WC >35" (women)	Ethnic-specific WC values** or BMI >30kg/m2	WHR >0.9 (men) WHR >0.85 (women) or BMI >30kg/m2
Triglycerides	≥150 mg/dL	≥150 mg/dL or treatment for hypertriglyceridemia	≥150 mg/dL
HDL	<40 mg/dL (men) <50 mg/dL (women)	<40 mg/dL (men) <50 mg/dL (women) or treatment for low HDL	<35 mg/dL (men) <40 mg/dL (women)
Blood Pressure	≥ 130/85 mmHg	≥ 130mmHg systolic or ≥85mmHg diastolic or treament for hypertension	≥ 140/90 mmHg or treament for hypertension
Fasting Glucose	≥ 110 mg/dL	≥ 100 mg/dL or diagnosis of Type II diabetes	N/A
Microalbuminuria	N/A	N/A	urniary albumin >20mg/mL or albumin/creatinine ratio >30 mg/g

*Insulin resistance includes glucose intolerance, impaired glucose intolerance, or diabetes

**Europids, Sub-Saharan Africans, Eastern Mediterranean, Middle East (men ≥ 94cm, women ≥ 80cm); South Asian, Chinese, Japanese (men ≥ 90cm, women ≥ 80cm); USA subjects will use the ATPIII values (men ≥ 102cm, women ≥88).

Sources: http://www.nhlbi.nih.gov/guidelines/cholesterol/atglance.pdf , http://www.americanheart.org/presenter.jhtml?identifier=4756 , http://www.idf.org/webdata/docs/MetS_def_update2006.pdf , http://www.idf.org/webdata/docs/IDF_Meta_def_final.pdf

2.2 Studies of Central Obesity Parameters

Although specific obesity parameters are not congruent among the different definitions of metabolic syndrome, experts concur on other metabolic syndrome components: obesity, insulin resistance, dyslipidemia, and hypertension. As shown in Table 1, the metabolic syndrome component of central obesity is identified by anthropometric parameters: BMI, WHR, or WC. Currently, some researchers have proposed another measurement, WHtR, is a more accurate measurement of central obesity for diabetes and CVD risk assessment.[34-36, 50-53]

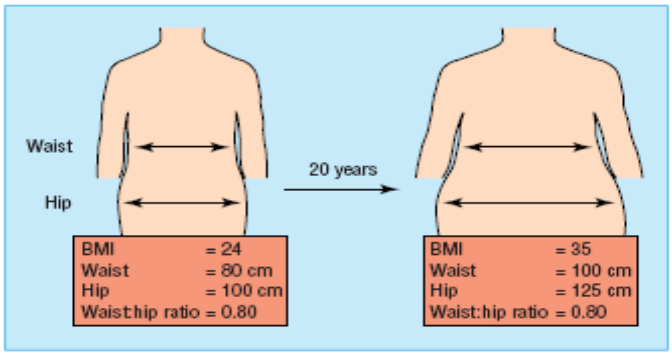
Before 1980, gender-specific weight-height tables were used to identify obese individuals.[54] These weight standards changed during 1980-1990 owing to increasing rates of obesity and obesity-related diseases. Based on descriptive statistics of obesity distribution and health outcomes, the United States Department of Health and Human Services and WHO reported that BMI, weight (kg) divided by height^2 (m), was a better predictor of body adiposity and a stronger estimator of relative risk for morbidity and mortality factors compared to weight-height.[54] The National Heart, Lung, and Blood Institute suggested that a BMI of $\geq$30 be used to identify individuals as obese.[55]

Although BMI is a useful estimator of obesity prevalence for large population studies, this obesity index has some limitations when estimating risk of CVD and metabolic disorders.[54] The measurement of body weight does not describe the distribution of body adiposity; weight does not discriminate lean body mass from excess body fat. For instance, an athletic person can appear overweight or obese because of excess muscle mass. On the other hand, an older person can appear normal weight due to a decrease in muscle mass from influences of aging. Numerous studies have demonstrated that BMI does not estimate central obesity and metabolic related disease as

well as other anthropometric measurements, such as WHR, WC, and WHtR.[32, 34, 35, 50, 56-61] Compared to total body fat indicators, central obesity is considered a better surrogate measurement of visceral adiposity, which is a risk factor for insulin resistance .[12, 62]

WHR is another commonly used central obese index. The WHR, a measurement of the waist circumference divided by the hip circumference, is recommended by WHO during metabolic syndrome screening. [17] The larger the ratio, the greater the tendency towards the higher risk android adiposity; the smaller the ratio, the greater the tendency towards gynoid adiposity. To describe the lower risk observed in gynoid phenotypes, experts hypothesize larger hip circumferences contain subcutaneous fat that acts as a sponge on circulating FFA.[12, 14, 62] In theory, this mechanism protect the liver and skeletal muscle from high levels of FFA and decreases the potential harmful affect on glucose uptake and insulin production. However, the WHR can be misleading with respect to how adiposity is distributed.[2] The hip circumference could mask the accumulation of abdominal adiposity if the hip circumference increases as well, as shown in Figure 1. In addition, the hip circumference does not differentiate between lean body mass and adiposity and therefore, may not accurately account for the inverse correlation between subcutaneous fat and insulin resistance.[40] Studies have demonstrated that WC and WHtR are better predictors of central obesity, more accurate proxies of visceral adiposity, and have stronger associations to metabolic syndrome components than WHR.[32, 53, 63]

Figure 1. Misleading estimation of abdominal adiposity by WHR



Source: Després J, Lemieux, I, Prud'homme, D. Treatment of obesity: need to focus on high risk abdominally obese patients. British Medical Journal. 2001;322:716–720.

Waist circumference is currently the designated indicator for central obesity in metabolic syndrome according to the two most common set of criterion: NCEP ATPIII and IDF guidelines.[58] Both expert groups use identical WC parameters to identify obese adults in the United States: ≥102cm (40 inches) for men and ≥88cm (35 inches) for women.[18, 19] IDF requires diagnosis of central obesity diagnosis to meet the definition of metabolic syndrome definition while NCEP ATPIII suggest individuals may be insulin resistant without being classified as centrally obese. IDF also recommends using ethnic-specific WC cut-points for diagnosis and statistical analysis, stemming from evidence of differences of intra-abdominal adiposity among racial/ethnic groups.[19, 44]

Although research has shown WC to be a robust measurement of central obesity and metabolic disorders,[30, 64] some investigators believe height in conjunction with WC is better correlated with visceral adiposity and metabolic risk.[32, 34, 35, 56] Ashwell and colleagues accurately measured 47 individuals' visceral adiposity via DEXA and found the WHtR was the anthropometric index most highly correlated with intra-abdominal fat compared to WC, BMI, and WHR (r = 0.83, 0.75, 0.69, and 0.54, respectively).[51]

Other studies comparing noninvasive anthropometric measurements have shown WHtR to be the strongest index associated with these metabolic disorders and CVD.[32, 50, 56] Hsieh et al. investigated 8,278 Japanese men and women of various age groups and assessed which index of central obesity identified subjects at a higher metabolic risk.[50] Based on previous Asian studies, researchers used a WHtR cut-point of ≥0.50 and found that individuals who were considered "normal" weight by BMI standards but centrally obese were at a statistically significant elevated risk for metabolic disorders. In addition, researchers reported decreases in BMI and increases in WHtR as age increased. The authors suggest obesity may be distorted by BMI due to muscle loss, while WHtR may be more representative of adiposity accumulation as age increases. Furthermore, female-to-male ratios of WHtR obesity index were closest to 1 across all age groups compared to BMI and WC, implying that the WHtR 0.50 cut-point was effective for both genders. Hence, the researchers concluded that a single WHtR may be a better parameter to identify metabolic risks across all age groups in both genders.[50]

A study conducted by Gracey and colleagues evaluated the WHtR, WC, and BMI indices as predictors of CVD in Australian Aborigines.[56] They found that obesity cut-points set at a WHtR ≥ 0.50 and a WC ≥90cm for men and ≥80cm for women were slightly better at discriminating for diabetes or CVD compared to BMI ≥22kg/m^2. However, the authors favored a WHtR parameter as opposed to WC, asserting that a single cut-point would allow easier implementation of public health strategies to decrease central obesity in both males and females.[56]

Using receiver-operating characteristic (ROC) analysis of classifiers, Schneider and colleagues demonstrated that an obese WHtR cut-off point between 0.54 and 0.59,

was the most sensitive index to predict metabolic syndrome, dyslipidemia, and Type 2 diabetes in German males and females, in all age groups, compared to WHR, hip circumference, WC, and BMI (0.70, 0.63, 0.63, 0.66, respectively).[32] The higher WHtR cut-point in the German study population (0.54-0.59) compared to other study populations (0.50) may be a reflection of the ethnic differences emphasized by the IDF regarding WC cut-points. Accordingly, a recent pilot study attempted to create a WHtR parameter that would factor in the ethnic variations of waist circumferences and stature.[37]

2.3 ICO Pilot Study

Parikh et al. in a pilot study (discussed previously) designed a new central obesity parameter, ICO, with the intention of determining why individuals within a certain ethnic group, with identical waist circumferences, have dissimilar risk for metabolic disorders.[37] "The ethnic difference that has led us to lower [WC] cutoffs may be essentially attributed to differences in average height".[37] Parikh and colleagues proposed measurement, ICO, uses a WHtR derived from the national average height divided by IDF's WC cut-points. The authors hypothesized that ICO correlated better with central obesity than WC, and designed an observational study on two individuals of the same ethnic group with the same WC.[37] Shown in Figure 2, the two subjects' body compositions are visually different with respect to height and girth. However, their WC and BMI measurements were identical, while their ICO, total body fat, and truncal fat measurements varied considerably, as reported in Table 2. In addition, Subject A had normal glucose levels while Subject B had hyperglycemia levels of 134 mg/dl. The authors concluded that their

stature variance, accounted for by ICO, influenced the difference in their adiposity distribution and glucose tolerance.[37]

Figure 2. Subject A (left), Subject B (right)

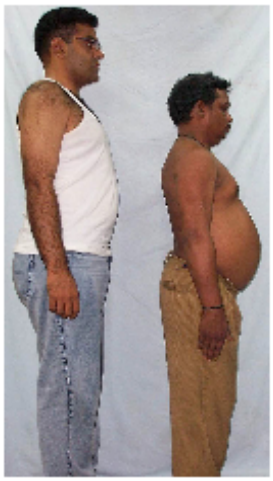


Table 2. Comparison of two subjects in the ICO pilot study

Parameter	Subject A	Subject B
BMI (kg/m2)	28.8	28.8
WC (cm)	98	98
ICO	0.557	0.645
Total Body Fat (kg)	26.2	15.8
Truncal Fat (kg)	9.5	7.4
TF in TBF (%)	36.11	46.31

BMI = Bmody Mass Index; WC = Waist Circumference; ICO Index of Central Obesity; TF = Truncal Fat; TBF = Total Body Fat

Source: Reprinted from Medical Hypotheses, 68, Rakesh M, Shashank R, Padmavathy S, and Nalini S, Index of Central Obesity – A Novel Parameter, 1272-1275, 2007, with permission from Elsevier

2.4 Summary

The literature demonstrates that WHtR may be a better parameter for identifying those at an elevated risk for metabolic disorders compared to WC, BMI, or WHR. Proponents for the WHtR emphasize the simplicity of using a single WHtR value to diagnose central obese individuals irrespective of age or gender. The WHtR cut-points of ICO were used in these studies as proposed by expert organizations and/or from ROC analysis. The discriminating factor between the WHtR evaluated in previous studies and the ICO evaluated in the pilot study is that the ICO assumes the average national height will account for ethnic differences and measure central obesity more accurately. Based on the literature, this study will analyze the relationship between ICO and metabolic syndrome components in white, black, and Hispanic adults in the United States.

CHAPTER III
METHODS AND PROCEDURES

3.1 Study Purpose

This cross-sectional study was designed to: (1) determine if the Index of Central Obesity has a stronger association with metabolic syndrome components compared to waist circumference among the white, black, and Hispanic adults in the United States; (2) determine race/ethnic specific differences with respect to the association between ICO and the metabolic syndrome components; and (3) assess if the relationship between ICO and metabolic syndrome components and varies by age.

3.2 Data Source

The data that was used in the study were obtained from the National Center for Health Statistics' (NCHS) National Health and Nutrition Examination Survey (NHANES). The NCHS was created in 1960 following Congress' National Health Survey Act of 1956, which required the collection of information to monitor illness and disabilities of the United States civilian non-institutionalized population. The nationwide, population-based survey collects data via interviews, clinical tests, measurements, and physical examinations.

From 1960 to 1970, the National Health Examination Surveys (NHES I, II, and III) were limited to specific age groups and certain illnesses. For example, NHES I was centered on chronic disease and adults 18-79 years of age, while NHES II and NHES III were centered on growth and development of children 6-11 years of age and 12-17 years of age, respectively. Stemming from the 1967 Senate hearings on Hunger in America, a

nutrition component was added to the survey due to links between dietary intake and disease. Starting in 1971, the name of the survey was changed to the National Health and Nutrition Examination Survey (NHANES). By 1999, NHANES evolved into a continuous annual survey of all ages to allow pertinent programmatic changes to accommodate emerging public health needs.

This study used data from the NHANES 2005-2006 interviews and examinations. The NHANES 2005-2006 survey design was a stratified, multistage probability sample made to represent the general US population. The multiple sample stages included: (1) selection of counties or small groups of counties, (2) block or group of blocks within those counties, (3) households within those blocks, and (4) one or more participants within those households. The 2005-2006 survey used higher sampling rates for low-income persons, persons 60+ years of age, African Americans, and Mexican Americans to increase the reliability and accuracy of statistical analysis for these groups.

During NHANES in-home interview portion, eligible participants signed consent forms and interviewers administered health questionnaires. Computer-Assisted Personal Interview technology was used to record participants' answers to the demographic, socioeconomic, dietary, and health-related questions. The health examination portion was conducted in Mobile Examination Centers (MECs) by professional medical teams. The examination collected health and nutrition information from physical exams, dietary interviews, and laboratory tests. In total, the NCHS surveyed 10,348 individuals of all ages between January 2005 and December 2006.

After the interview and examination data were collected and processed, The Centers for Disease Control and Prevention (CDC) posted the results in a publicly

accessible SAS transport file format on their website (http://www.cdc.gov/nchs/nhanes.htm). All information collected from the NHANES 2005-2006 for this study was secondary, de-identified data and downloaded into SPSS® 15.0. For our research purposes, population delimitations were established to include only white, black, and Hispanic American adults, 20 years of age and older, with waist and height measurements documented. Of the 10,348 subjects in NHANES 2005-2006, only 1,919 female and 1,777 males met the criteria for this study.

3.3 Study Variables

(3.3.a.) Demographic Variables

Demographic/socioeconomic variables included in this study were age, gender, race/ethnicity, education, income, and insurance. Age was recoded into categories, of young, middle, and older age groups (AGEGP: 1 = 20 to 39 years of age, 2 = 40 to 59 years of age, 3 = 60 or older). Analysis was stratified by gender (1 = male, 2 = female) due to differences in obesity parameters and clinical parameters between the sexes. Race/ethnicity was recoded as "1" for Non-Hispanic White, "2" for Non-Hispanic Black, and "3" for Mexican American and other Hispanic. Other variables that were used in this study include education (EDU: 1 = less than high school, 2 = high school degree or GED, 3 = more than a high school education), annual household income (INC: 1 = $0-$19,999, 2 = $20,000-$44,999, 3 = $45,000-$74,999, 4 = $75,000 or more), health insurance coverage (INS: 1 = yes, 0 = no), and Medicare or Medicaid coverage (GOVINS: 1 = yes, 0 = no).

(3.3.b.) Anthropometric Variables

Anthropometric measurements necessary to identify obese versus non-obese subjects included height, weight, and waist circumference. During the NHANES physical examination, standing height (HT) was determined at the maximum vertical size measured in centimeters via a fixed stadiometer with a vertical backboard and moveable headboard.[65] Waist circumference (WC) was measured in centimeters from the horizontal line above the uppermost lateral border of the right ilium.[65] To capture those with abdominal obesity, WC was transformed into an obese waist circumference variable (MS_ObeseWC). MS_ObeseWC was coded as "1" indicating obesity if males measured at least 102cm or if females measured at least 88cm, in accordance with IDF guidelines.[19] Subjects who did not have an obese waistline were coded as "0". Waist-to-Height Ratio (WHtR) was computed by dividing the WC by the HT. To classify those with central obesity, an ICO status variable (MS_ObeseICO) was created by using parameters that were used in a previous pilot study.[37] Similar to the pilot study, the ICO parameters were computed by taking NHANES 2005-2006 average height of the American male adult, 176cm, and the American female adult, 162cm, divided by the IDF obese WC gender cutoffs (≥102cm for men, ≥88cm for women). MS_ObeseICO was coded as "1" if the WHtR was at or above the cutoff of 0.58 for men and 0.54 for women. Those with WHtR's below these values were not considered obese and were coded as "0". BMI (Obese_BMI), was calculated as weight(kg)/height^2 (m) and coded as obese if values were at or above 30.

(3.3.c.) Behavioral Variables

Variables used to describe behavioral characteristics were cigarette smoking, alcohol use, and physical activity. "Cigarette Smoker" was defined as someone who self reported smoking 100 or more cigarettes in their lifetime. "Alcohol Use" was defined as the average weekly alcohol consumption, derived from the subjects' responses to drinking questions. Average weekly alcohol consumption was calculated by multiplying the number of days a subject drinks (per week, month, or year), by the average number of drinks during those days, by the unit of time (52 weeks or 12 months or 1 year), and dividing by 52 weeks. "Physical Activity" was determined using the number of times subjects self-reported specific physical activities at a moderate or vigorous level in the past 30 days. Physical activities included: aerobics, baseball, basketball, bicycling, bowling, dance, fishing, football, gardening, golf, hiking, hockey, hunting, jogging, kayaking, push-ups, racquetball, rollerblading, rowing, running, sit-ups, skating, skiing cross country, skiing downhill, soccer, softball, stair climbing, stretching, swimming, tennis, treadmill, volleyball, walking, weight lifting, yard work, boxing, frisbee, horseback riding, martial arts, wrestling, yoga, cheerleading/gymnastics, rope jumping, skateboarding, surfing, trampoline jumping, and other.

(3.3.d.) Medical History Variables

Medical history included variables of both individual and family history of diabetes, heart disease, and stroke. Subjects who were previously diagnosed with diabetes or a stroke were coded as having a history of diabetes or a history of a stroke respectively. Subjects who were previously diagnosed with coronary heart disease, angina, or heart attack were coded as having a history of heart disease. The presence of family history included an occurrence of diabetes or heart attack in a close biological family member.

(3.3.e.) Clinical Variables

Clinical variables essential to metabolic syndrome components included systolic and diastolic blood pressure, serum triglyceride, HDL levels, and fasting blood glucose. For this study, the IDF definition and cutoffs for metabolic syndrome components were used with some exception. Systolic and diastolic blood pressure readings were administered one to four times during the examination. The raised blood pressure variable (MS_HighHBP) was an average of both the systolic and diastolic blood pressure readings. If the systolic average was ≥135mmHg or the diastolic average was ≥85mmHg or the subject reported taking hypertension medication, they were coded as having raised blood pressure. Individuals with triglyceride levels ≥150mg/dL were categorized as having raised triglycerides (MS_HighTri). However, subjects on a cholesterol medicine regimen were not regarded as having raised triglycerides due to lack of information concerning the cholesterol type targeted. Subjects with HDL levels below 40mg/dL for men and 50mg/dL for women were defined as having abnormal reduced HDL (MS_LowHDL). The same omission of those on a cholesterol medicine regimen applied with this metabolic syndrome component. Individuals with fasting blood glucose levels recorded as ≥100mg/dL or previously diagnosed diabetes were identified as having raised fasting blood glucose (MS_HighGlucose).

3.4 Statistical Analysis

All statistical analysis was conducted using SPSS® 15.0. Tables and figures were created using both SPSS® 15.0 and Microsoft® Office Excel 2003. All analysis was gender specific due to gender differences in body composition and blood lipid profile.

Characteristics of study populations were evaluated using demographic variables (age, education level, income level, insurance status, Medicaid/Medicare status), behavioral factors (cigarette smoking history, alcohol use, physical activity), medical history (personal history of diabetes, heart disease, stroke; family history of diabetes, heart attack), anthropometric measurements (waist circumference, height, waist-to-height ratio, obese waist circumference, obese ICO, and obese BMI), and clinical measurements (raised blood pressure, raised triglycerides, reduced HDL, raised fasting blood glucose). For both males and females, characteristics were analyzed in three different formats: (1) differences between racial/ethnic subgroups, (2) differences between obese and not obese subgroups, and (3) differences between racial/ethnic subgroups of the obese study population. Differences of continuous variables among the subgroups were tested at the 0.05 significance level using one-way analysis of variance (ANOVA) in racial/ethnic group stratification (white, black, Hispanic) and independent t-tests in ICO status stratification (obese/not obese). Results were reported in terms of means and standard deviations ($\mu \pm SD$). Differences between categorical variables among the subgroups were tested at the 0.05 significance level using chi-square and reported as a proportion of the study population.

To evaluate the strength of the relationship between the independent variable (ICO) and the dependent variables (metabolic syndrome components), correlation analyses were performed. To measure the strength of association between ICO and metabolic syndrome components among races/ethnicities, a two-tailed partial correlation test using Pearson's correlation analyses were conducted controlling for age. To evaluate the strength of relationship between the same independent and dependent variables with

respect to age, a two-tailed bivariate correlation analyses was performed using Spearman's Rho correlation coefficient in each age group (20-39, 40-59, 60+) stratified by race/ethnic group. Correlations that were statistically significant were noted at both the 0.01 level and the 0.05 level of probability.

Odds ratios (OR) were calculated at the 95% confidence level to quantify the association of central obesity and with each metabolic syndrome component. Univariate and multivariate logistic regression were performed to determine association between dependent and independent variables. The OR for whites, blacks, and Hispanics was calculated. In the multivariate regression analyses, statistical adjustments were made for age, education level, income level, health insurance status, history of cigarette smoking, alcohol use, and physical activity. In both univariate and multivariate analysis, WC and ICO were analyzed separately as the independent variable to allow estimations of OR differences. The 95% confidence level was used to determine statistical significance.

CHAPTER IV
RESULTS

4.1 Basic Characteristics

The basic demographic factors, anthropometric measurements, behavioral factors, medical history, and clinical factors of the eligible males and females are shown in Table 3 and Table 4 respectively. White, black, and Hispanic subjects were statistically different with respect to age, education level, income level, insurance status, and Medicare/Medicaid status. Hispanic men and women were younger, had a lower education level, and had the highest uninsured rates compared to their white and black counterparts ($p<0.01$). White males and females tended to be older and at a higher socioeconomic status than their black and Hispanic counterparts ($p<0.01$).

Except for male BMI, all anthropometric measurements were statistically different between white, black, and Hispanic subjects. Among males, whites had larger waists (mean, 103cm) and higher rates of abdominal obesity (50%) than blacks and Hispanics ($p<0.05$). Among females, blacks had larger waist measurements (mean, 100cm) and higher rates of abdominal obesity (73%) compared to whites and Hispanics ($p<0.001$). In both men and women, Hispanics had the shortest stature among the races/ethnicities ($p<0.01$).

Racial/ethnic differences were evident with respect to the history of heart disease among males and the history of diabetes and family history of diabetes among males and females ($p<0.05$). Compared to white subjects, blacks and Hispanics were twice as likely to have diabetes ($p<0.001$). Within the male population, whites were at least 1.5 times

more likely to have a history of heart disease among the three races/ethnicities ($p<0.05$). Racial/ethnic differences in all other medical history were not statistical significant.

Racial/ethnic differences in rates of metabolic syndrome components (raised blood pressure, raised triglycerides, reduced HDL, and raised fasting blood glucose) were statistically significantly at the 0.01 level of probability with exception to glucose levels within male subjects ($p=0.08$). Raised blood pressure was more prevalent in blacks and affected 51% of black males and 47% of black females ($p<0.001$). Dyslipidemia and hyperglycemia were more common in Hispanics compared to whites and blacks. In males, Hispanics were approximately 2.2 times more likely to have raised triglycerides and 2.3 times more likely to have reduced HDL levels than black males ($p<0.001$). In females, Hispanics were 1.5 times more likely to have raised fasting blood glucose than whites, and 2.3 times more likely to have raised triglycerides and 1.6 times more likely to have reduced HDL than blacks ($p<0.001$).

Table 3. Characteristics of the Male Study Population by Race, NHANES 2005-2006

			White (n = 1078)	Black (n = 460)	Hispanic (n = 239)	p-value*
Demographic Factors	Age (years)[1]		53 ± 19	48 ± 17	47 ± 18	<.001
	Education:	*< high school*	17.1%	29.1%	42.3%	<.001
		high school	26.3%	27.6%	17.2%	
		> high school	56.7%	43.3%	40.6%	
	Income:	*<$20,000*	16.9%	18.8%	17.0%	0.008
		$20,000-$44,999	28.6%	34.3%	38.3%	
		$45,000-$74,999	24.3%	23.6%	24.3%	
		≥ $75,000	30.2%	23.3%	20.4%	
	Covered by Insurance		84.7%	77.2%	74.9%	<.001
	Covered by Medicare/Medicaid		34.8%	25.0%	23.0%	<.001
Behavioral Factors	History of Smoking[2]		62.4%	53.7%	51.5%	<.001
	Alcohol Use[3]		6 ± 11	4 ± 9	5 ± 8	0.003
	Physical Activity[4]		11 ± 15	13 ± 16	15 ± 28	0.017
Medical History	History of Diabetes		7.7%	15.9%	15.7%	<.001
	History of Heart Disease		12.4%	8.9%	6.7%	0.012
	History of Stroke		4.1%	4.6%	3.3%	0.742
	Family History of Diabetes		34.1%	47.8%	51.1%	<.001
	Family History of Heart Attack		15.8%	12.1%	11.5%	0.074
Anthropometric Measurements	Waist Circumference[1] (cm)		102.7 ± 15.0	100.0 ± 16.9	101.1 ± 14.3	0.005
	Height[1] (cm)		176.5 ± 7.2	177.2 ± 7.4	171.4 ± 7.0	<.001
	WtHR[1, 5]		0.58 ± .09	0.56 ± .09	0.59 ± .08	<.001
	Obese Waist Circumference[6]		49.9%	43.3%	42.3%	0.015
	Obese ICO[7]		48.6%	40.7%	49.4%	0.011
	Obese BMI [8]		31.6%	37.8%	33.1%	0.062
Clinical Measurements	Raised Blood Pressure[6]		43.7%	50.7%	32.6%	<.001
	Raised Triglycerides[6]		42.3%	24.8%	54.4%	<.001
	Reduced HDL[6]		23.7%	13.1%	30.3%	<.001
	Raised Fasting Blood Glucose[6]		29.4%	31.7%	36.8%	0.075

***** p-values for continuous variables and categorical variables are from oneway ANOVA and chi-square, respectively; **(1)** μ ± SD; **(2)** Smoked at least 100 cigarettes in lifetime; **(3)** Average number of alcohol drinks consumed per week, **(4)** Number of moderate or vigourous activites performed in the past 30 days; **(5)** Waist-to-Height Ratio = waist circumference (cm) / height (cm); **(6)** Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥102 cm); **(7)** Index of Central Obesity for men = waist circumference cutoff / average national height ≥ 0.58; **(8)** Obese Body Mass Index (BMI) ≥ 30

Table 4. Characteristics of the Female Study Population by Race, NHANES 2005-2006

			White (n = 1120)	Black (n = 503)	Hispanic (n = 296)	p-value*
Demographic Factors	Age (years)[1]		50 ± 20	46 ± 17	44 ± 17	<.001
	Education:	*< high school*	13.2%	25.8%	33.4%	<.001
		high school	26.3%	19.9%	27.4%	
		> high school	60.5%	54.3%	39.2%	
	Income:	*<$20,000*	17.6%	27.7%	24.3%	<.001
		$20,000-$44,999	27.3%	30.2%	35.1%	
		$45,000-$74,999	25.3%	24.0%	20.3%	
		≥ $75,000	29.8%	18.2%	20.3%	
	Covered by Insurance		89.6%	82.9%	81.0%	<.001
	Covered by Medicare/Medicaid		31.6%	31.4%	22.0%	0.004
Behavioral Factors	History of Smoking[2]		47.7%	33.5%	33.8%	<.001
	Alcohol Use[3]		2 ± 4	2 ± 9	1 ± 2	0.036
	Physical Activity[4]		12 ± 17	13 ± 14	12 ± 13	0.929
Medical History	History of Diabetes		7.1%	13.1%	14.5%	<.001
	History of Heart Disease		6.2%	6.4%	3.0%	0.094
	History of Stroke		3.7%	4.0%	3.0%	0.792
	Family History of Diabetes		38.6%	55.5%	57.7%	<.001
	Family History of Heart Attack		17.1%	12.6%	14.1%	0.061
Anthropometric Measurements	Waist Circumference[1] (cm)		94.9 ± 16.1	99.8 ± 17.4	96.1 ± 14.4	<.001
	Height[1] (cm)		162.8 ± 6.7	162.4 ± 6.5	158.2 ± 6.5	<.001
	WtHR[1, 5]		0.58 ± 0.10	0.61 ± 0.11	0.61 ± 0.10	<.001
	Obese Waist Circumference[6]		63.5%	73.2%	69.6%	<.001
	Obese ICO[7]		64.5%	72.0%	76.0%	<.001
	Obese BMI [8]		32.4%	53.7%	40.9%	<.001
Clinical Measurements	Raised Blood Pressure[6]		36.1%	47.1%	25.7%	<.001
	Raised Triglycerides[6]		39.1%	17.6%	41.3%	<.001
	Reduced HDL[6]		24.0%	21.7%	35.8%	<.001
	Raised Fasting Blood Glucose[6]		18.8%	25.4%	28.4%	<.001

***** p-values for continuous variables and categorical variables are from oneway ANOVA and chi-square, respectively; **(1)** μ ± SD; **(2)** Smoked at least 100 cigarettes in lifetime; **(3)** Average number of alcohol drinks consumed per week, **(4)** Number of moderate or vigourous activites performed in the past 30 days; **(5)** Waist-to-Height Ratio = waist circumference (cm) / height (cm); **(6)** Metabolic Syndrome Components for women: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<50 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥88 cm); **(7)** Index of Central Obesity for women = waist circumference cutoff / average national height ≥ 0.54; **(8)** Obese Body Mass Index (BMI) ≥ 30

Age-specific (young adults, middle-aged adults, and older adults) prevalence of ICO in the eligible men and women are shown in Figure 3 and Figures 4, respectively. A shown, a positive linear relationship is evident: as age increases, the proportion of ICO cases increases. Figure 3 shows the prevalence of ICO increases nearly 50% as age increases from the youngest to the oldest group of the obese males. Figure 4 shows a smaller increase (25%) of ICO prevalence between the youngest and oldest group of obese females. Although the increase is not as substantial in the females, young female adults are twice as likely to be obese as compared to their male counterparts.

Figure 3. Index of Central Obesity $\geq$ 0.58 in Adult Males by Age Group, NHANES 2005-2006

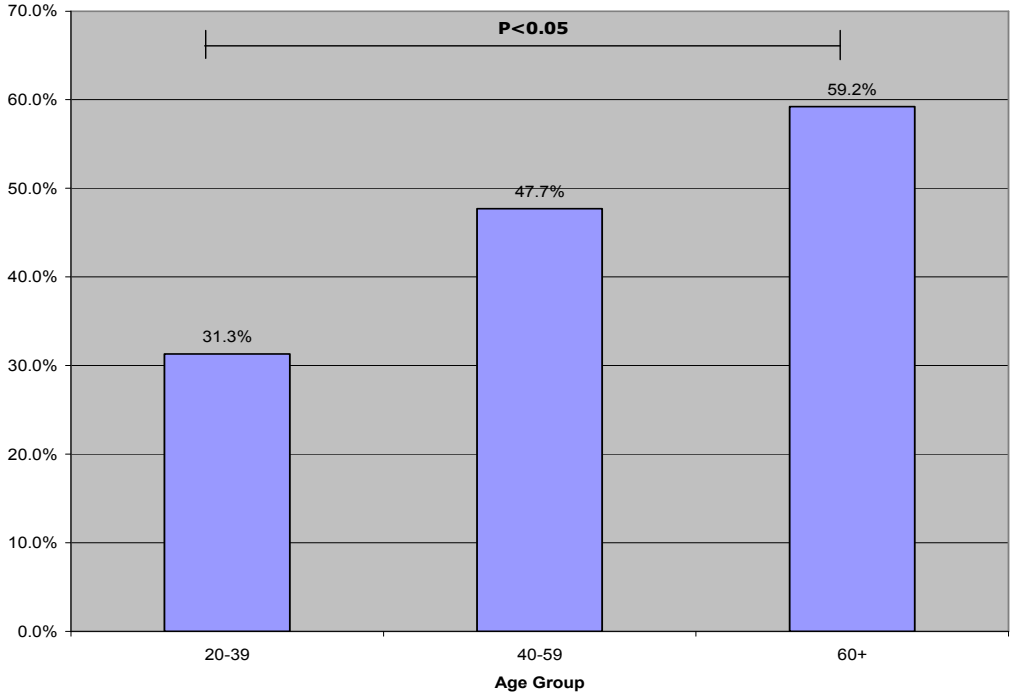
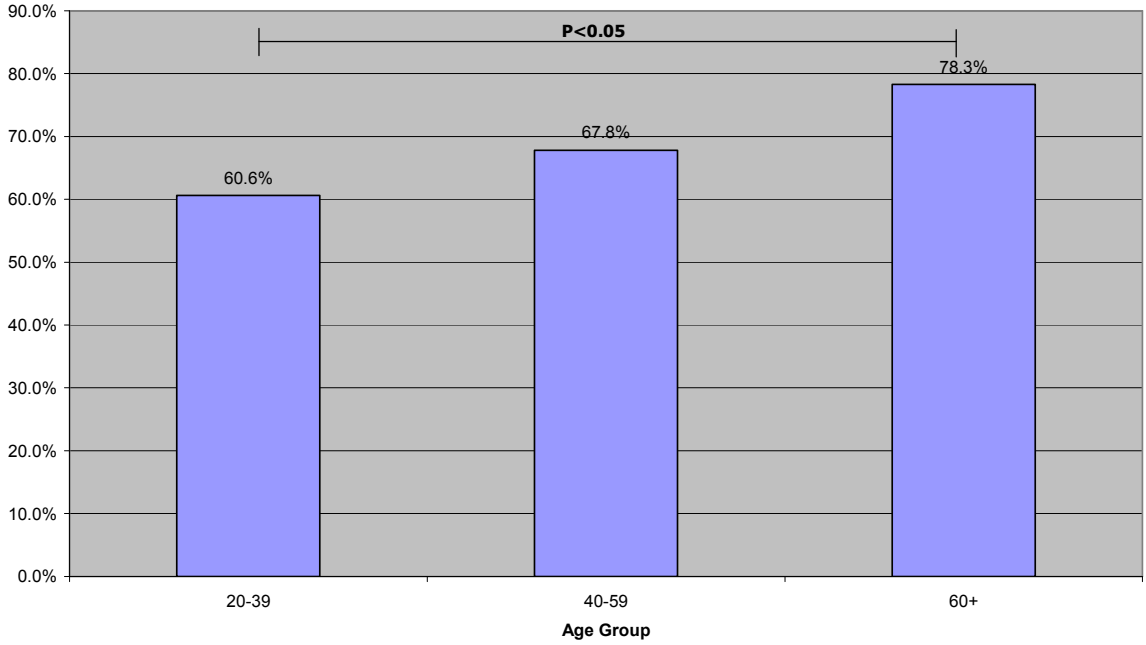


Figure 4. Index of Central Obesity ≥ 0.54 in Adult Females by Age Group, NHANES 2005-2006



In Figure 5 and Figure 6, comparison of the rate of ICO in white, black, and Hispanics in the males and females are shown respectively. In men, no differences in obesity rates were observed in white and Hispanic, while black men presented with approximately 10% smaller rates of ICO compared to white and Hispanic men. In women, significant different rates of ICO are apparent with white females having fewer subjects with ICO. Irrespective of race/ethnicity, obesity was more prevalent across white, black, and Hispanic females (over 60%) versus the males (under 50%).

Figure 5. Rate of ICO of White, Black, and Hispanic Men, NHANES 2005-2006

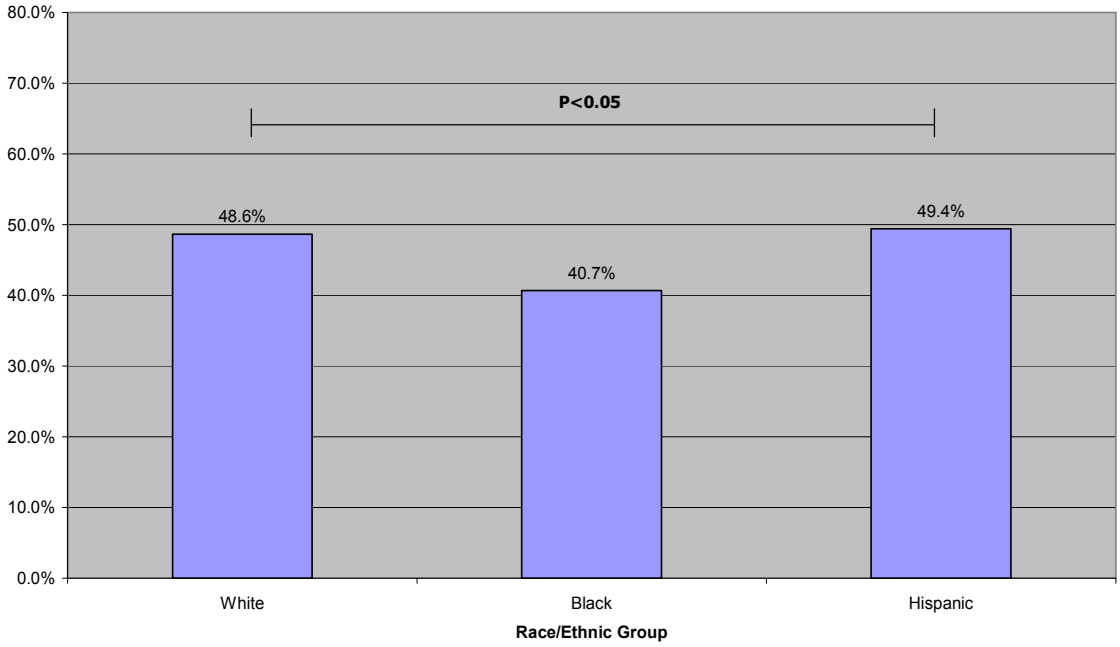
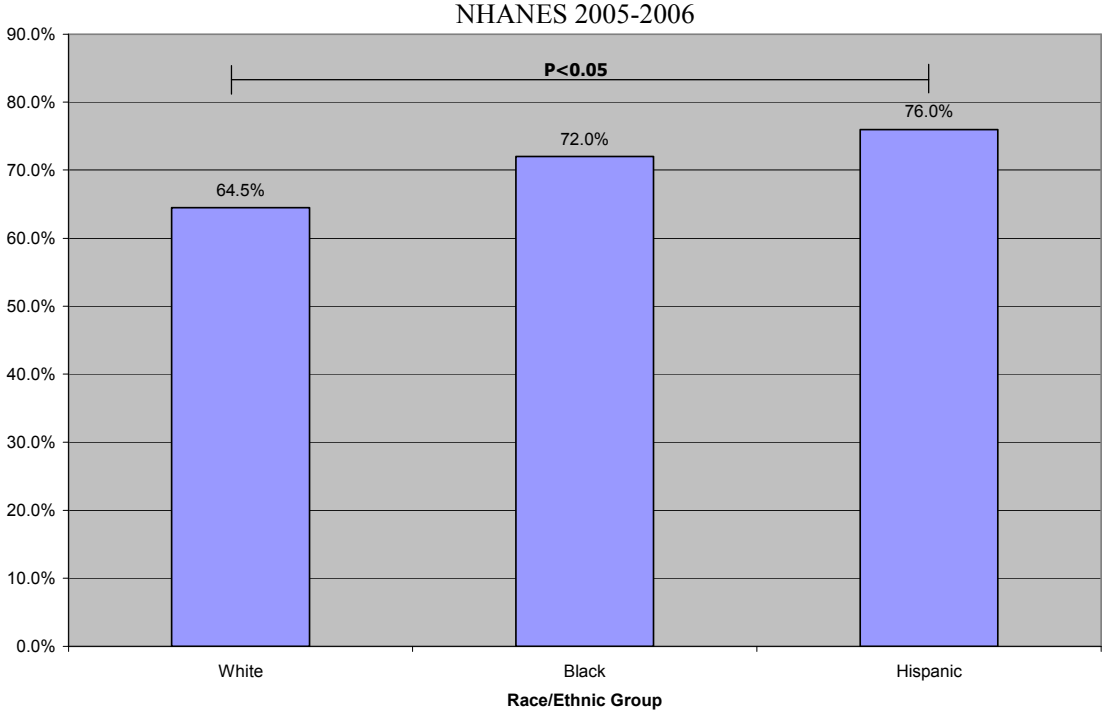


Figure 6. Rate of ICO of White, Black, and Hispanic Women, NHANES 2005-2006



To further delineate differences between obese and non-obese subjects, the study population was stratified by ICO parameters defined by a WHtR at or above 0.58 for males and 0.54 for females. Differences in characteristics between the male obese (47%) and non-obese (53%) subjects are shown in Table 5 and the female obese (68%) and non-obese (32%) subjects are shown in Table 6. With exception of income in males, obese and non-obese subjects differed with respect to all demographic variables that were studied ($p<0.05$). The obese subjects tended to be older, less educated, and more likely to have health insurance.

As expected, anthropometric measurements varied between obese and non-obese subjects ($p<0.001$). In males, 91% of obese males had an obese waist circumference ($\geq$102), averaging 23cm larger than non-obese males. In females, 94% had an obese waist circumference ($\geq$88cm) and were an average 25cm larger than the non-obese. A smaller proportion of ICO obese subjects were considered BMI obese: 67% of central obese males and 57% of central obese females had BMI $\geq$30.

Fewer non-obese subjects reported a history of diabetes, heart disease, stroke, family history of diabetes, and family history of heart attacks compared to obese subjects ($p<0.05$). Obese males and females were approximately 3 times more likely to have a history of diabetes, 2 times more likely to have a history of heart disease, and 3 times more likely to have a history of stroke than their non-obese counterparts ($p<0.001$). As anticipated, obese subjects demonstrated higher rates of metabolic syndrome components. In males, obese subjects were nearly 2 times more likely to have raised blood pressure, raised triglycerides, reduced HDL, or raised fasting blood glucose in relation to non-obese subjects ($p <0.001$). In females, obese subjects were approximately

2 times more likely to have either raised blood pressure or reduced HDLS and approximately 3 times more likely to have raised triglycerides or raised fasting blood glucose compared to non-obese subjects ($p<0.001$).

Table 5. Characteristics of the Male Study Population by Index of Central Obesity (ICO)[1], NHANES 2005-2006

			Not Obese (n = 948)	Obese (n = 829)	p-value*
Demographic Factors	Age (years)[2]		47 ± 19	56 ± 17	<.001
	Education:	*< high school*	22.0%	25.3%	0.021
		high school	23.8%	27.1%	
		> high school	54.1%	47.5%	
	Income:	*<$20,000*	17.0%	17.8%	0.832
		$20,000-$44,999	30.8%	32.1%	
		$45,000-$74,999	24.3%	23.8%	
		≥ $75,000	27.9%	26.2%	
	Covered by Insurance		77.4%	86.0%	<.001
	Covered by Medicare/Medicaid		23.4%	39.0%	<.001
Behavioral Factors	History of Smoking[3]		58.1%	59.3%	0.317
	Alcohol Use[4]		6 ± 12	4 ± 9	<.001
	Physical Activity[5]		11 ± 18	13 ± 16	0.159
Medical History	History of Diabetes		6.1%	16.5%	<.001
	History of Heart Disease		6.5%	15.6%	<.001
	History of Stroke		2.1%	6.4%	<.001
	Family History of Diabetes		34.3%	46.5%	<.001
	Family History of Heart Attack		12.5%	16.3%	0.015
Anthropometric Measurements	Waist Circumference[2] (cm)		91 ± 9	114 ± 12	<.001
	Height[2] (cm)		177 ± 7	175 ± 8	<.001
	WtHR[2, 6]		0.51 ± .05	0.65 ± .06	<.001
	Obese Waist Circumference[7]		8.8%	91.1%	<.001
	Obese BMI [8]		3.9%	67.2%	<.001
Clinical Measurements	Raised Blood Pressure[7]		32.7%	56.9%	<.001
	Raised Triglycerides[7]		28.7%	51.5%	<.001
	Reduced HDL[7]		15.6%	28.9%	<.001
	Raised Fasting Blood Glucose[7]		23.2%	39.9%	<.001

***** p-values for continuous variables and categorical variables are from independent t-test and chi-square, respectively; **(1)** ICO Status = obese (≥ 0.58) or not obese (< 0.58); **(2)** μ ± SD; **(3)** Smoked at least 100 cigarettes in lifetime; **(4)** Average number of alcohol drinks consumed per week; **(5)** Number of moderate or vigourous activites performed in the past 30 days; **(6)** Waist-to-Height Ratio = waist circumference (cm) / height (cm); **(7)** Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥102 cm); **(8)** Obese Body Mass Index (BMI) ≥ 30

Table 6. Characteristics of the Female Study Population by Index of Central Obesity (ICO)[1], NHANES 2005-2006

			Not Obese (n = 610)	Obese (n = 1309)	p-value*
Demographic Factors	Age (years)[2]		43 ± 18	50 ± 19	<.001
	Education:	*< high school*	13.5%	22.5%	<.001
		high school	20.9%	26.6%	
		> high school	65.7%	50.9%	
	Income:	*<$20,000*	18.2%	22.7%	<.001
		$20,000-$44,999	23.6%	31.8%	
		$45,000-$74,999	21.9%	25.3%	
		≥ $75,000	36.3%	20.2%	
	Covered by Insurance		84.4%	87.5%	0.038
	Covered by Medicare/Medicaid		20.2%	34.7%	<.001
Behavioral Factors	History of Smoking[3]		43.7%	40.9%	0.140
	Alcohol Use[4]		3 ± 8	2 ± 4	<.001
	Physical Activity[5]		12 ± 15	13 ± 16	0.469
Medical History	History of Diabetes		3.6%	12.7%	<.001
	History of Heart Disease		3.1%	7.0%	<.001
	History of Stroke		1.5%	4.7%	<.001
	Family History of Diabetes		37.2%	50.1%	<.001
	Family History of Heart Attack		12.2%	17.0%	0.004
Anthropometric Measurements	Waist Circumference[2] (cm)		79 ± 6	104 ± 13	<.001
	Height[2] (cm)		163 ± 7	161 ± 7	<.001
	WtHR[2, 6]		0.49 ± .04	0.65 ± .08	<.001
	Obese Waist Circumference[7]		8.5%	94.2%	<.001
	Obese BMI [8]		0.5%	57.4%	<.001
Clinical Measurements	Raised Blood Pressure[7]		22.6%	44.2%	<.001
	Raised Triglycerides[7]		14.1%	43.1%	<.001
	Reduced HDL[7]		13.1%	30.8%	<.001
	Raised Fasting Blood Glucose[7]		10.0%	27.6%	<.001

***** p-values for continuous variables and categorical variables are from independent t-test and chi-square, respectively; **(1)** ICO Status = obese (≥ 0.54) or not obese (< 0.54); **(2)** μ ± SD; **(3)** Smoked at least 100 cigarettes in lifetime; **(4)** Average number of alcohol drinks consumed per week; **(5)** Number of moderate or vigourous activites performed in the past 30 days; **(6)** Waist-to-Height Ratio = waist circumference (cm) / height (cm); **(7)** Metabolic Syndrome Components for women: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<50 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥88 cm); **(8)** Obese Body Mass Index (BMI) ≥ 30

To define racial/ethnic variations among the obese study population, the same descriptive variables were stratified by white, black, and Hispanics. Table 7 and Table 8 show the basic description of the 829 obese males (63% white, 23% black, 14% Hispanic) and the 1309 obese females (55% whites, 28% blacks, 17% Hispanics) in that order. A majority of studied characteristics were significantly different between the three obese subgroups. The average physical activity, rate of heart disease, rate of stroke, family history of heart attacks, and rate of hyperglycemia did not vary between white, black, and Hispanic obese subjects ($p>0.05$). In addition, income and WHtR did not vary among the males while alcohol use did not vary among the females ($p>0.05$).

White, black, and Hispanic obese subjects were statistically different with respect to demographic factors. On stratifying for ICO, white subjects remained older, more educated, and more likely to have health insurance among all three races/ethnicities ($p<0.01$) Hispanic subjects remained younger, with the least education, and least likely to have health insurance ($p<0.01$).

Body composition differences were significant between the white, black, and Hispanic obese subjects ($p<0.05$) with exception to the males' WHtR. Among the three subgroups, obese black subjects were inclined to have larger anthropometric measurements while obese Hispanic subjects tended to be smaller in stature and waist measurements. In addition, variation in central obesity prevalence depended on the type of indicator. For example, 20% of Hispanic males with an obese ICO were not obese according to WC measurements compared to only 5% of black males.

Racial/ethnic differences among the obese subjects were observed in the history of diabetes, history of heart disease, and family history of diabetes ($p <0.05$). Among the

three races/ethnicities, heart disease was most prevalent in obese white males and females while diabetes was most prevalent in obese black males and obese Hispanic females. The rate of metabolic syndrome components, with exception to blood glucose levels, varied between the obese white, black, and Hispanic ($p<0.001$) as well. Obese black subjects had higher rates of raised blood pressure while obese Hispanic subjects had higher rates of raised triglycerides and reduced HDL levels.

Table 7. Characteristics of the Obese Male Study Population by Race, ICO ≥ 0.58, NHANES 2005-2006

			White (n = 524)	Black (n = 187)	Hispanic (n = 118)	p-value*
Demographic Factors	Age (years)[1]		58 ± 17	51 ± 17	50 ± 17	<.001
	Education:	*< high school*	19.8%	27.8%	45.8%	<.001
		high school	27.5%	31.0%	19.5%	
		> high school	52.7%	41.2%	34.7%	
	Income:	*<$20,000*	17.5%	18.7%	17.9%	0.259
		$20,000-$44,999	29.8%	35.2%	37.5%	
		$45,000-$74,999	23.9%	22.0%	26.8%	
		≥ $75,000	28.8%	24.2%	17.9%	
	Covered by Insurance		89.7%	81.3%	77.1%	<.001
	Covered by Medicare/Medicaid		43.1%	32.1%	31.4%	0.005
Behavioral Factors	History of Smoking[2]		63.9%	50.3%	53.4%	0.002
	Alcohol Use[3]		5 ± 10	3 ± 6	3 ± 6	0.036
	Physical Activity[4]		12 ± 17	14 ± 15	13 ± 12	0.630
Medical History	History of Diabetes		12.9%	23.9%	20.9%	0.001
	History of Heart Disease		17.7%	13.9%	8.5%	0.033
	History of Stroke		5.5%	9.6%	5.1%	0.120
	Family History of Diabetes		42.0%	56.4%	50.4%	0.003
	Family History of Heart Attack		18.0%	13.8%	13.0%	0.255
Anthropometric Measurements	Waist Circumference[1] (cm)		114 ± 12	115 ± 12	111 ± 12	0.003
	Height[1] (cm)		175 ± 7	177 ± 8	170 ± 7	<.001
	WtHR[1, 5]		0.65 ± 0.06	0.66 ± 0.06	0.65 ± 0.07	0.829
	Obese Waist Circumference[6]		92.2%	95.2%	79.7%	<.001
	Obese BMI[7]		62.6%	81.8%	64.4%	<.001
Clinical Measurements	Raised Blood Pressure[6]		57.8%	65.8%	39.0%	<.001
	Raised Triglycerides[6]		54.0%	34.4%	67.3%	<.001
	Reduced HDL[6]		29.9%	17.8%	42.1%	<.001
	Raised Fasting Blood Glucose[6]		38.5%	41.7%	43.2%	0.550

***** p-values for continuous variables and categorical variables are from oneway ANOVA and chi-square, respectively; **(1)** μ ± SD; **(2)** Smoked at least 100 cigarettes in lifetime; **(3)** Average number of alcohol drinks consumed per week, **(4)** Number of moderate or vigourous activites performed in the past 30 days; **(5)** Waist-to-Height Ratio = waist circumference (cm) / height (cm); **(6)** Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥102 cm); **(7)** Obese Body Mass Index (BMI) ≥ 30

Table 8. Characteristics of the Obese Female Study Population by Race, ICO ≥ 0.54, NHANES 2005-2006

			White (n = 722)	Black (n = 362)	Hispanic (n = 225)	p-value*
Demographic Factors	Age (years)[1]		52 ± 20	48 ± 17	45 ± 17	<.001
	Education:	*< high school*	15.5%	27.3%	37.3%	<.001
		high school	29.1%	20.7%	28.0%	
		> high school	55.4%	51.9%	34.7%	
	Income:	*<$20,000*	19.0%	28.4%	25.2%	0.001
		$20,000-$44,999	30.5%	31.6%	36.7%	
		$45,000-$74,999	27.0%	24.1%	21.4%	
		≥ $75,000	23.5%	15.8%	16.7%	
	Covered by Insurance		92.1%	83.4%	79.5%	<.001
	Covered by Medicare/Medicaid		37.7%	35.1%	24.4%	0.001
Behavioral Factors	History of Smoking[2]		47.2%	33.1%	33.3%	<.001
	Alcohol Use[3]		2 ± 4	1 ± 5	1 ± 3	0.092
	Physical Activity[4]		13 ± 18	13 ± 15	12 ± 12	0.757
Medical History	History of Diabetes		10.0%	14.4%	18.6%	0.002
	History of Heart Disease		8.2%	6.9%	3.1%	0.033
	History of Stroke		5.1%	4.4%	3.6%	0.602
	Family History of Diabetes		43.4%	58.2%	58.6%	<.001
	Family History of Heart Attack		18.7%	14.2%	15.7%	0.162
Anthropometric Measurements	Waist Circumference[1] (cm)		104 ± 13	107 ± 14	101 ± 12	<.001
	Height[1] (cm)		162 ± 7	162 ± 6	158 ± 6	<.001
	WtHR[1, 5]		0.64 ± .08	0.66 ± .09	0.64 ± .08	<.001
	Obese Waist Circumference[6]		94.0%	96.7%	90.7%	0.010
	Obese BMI [7]		50.0%	74.3%	53.8%	<.001
Clinical Measurements	Raised Blood Pressure[6]		44.6%	53.6%	28.0%	<.001
	Raised Triglycerides[6]		51.9%	21.4%	48.4%	<.001
	Reduced HDL[6]		30.4%	25.7%	39.8%	0.002
	Raised Fasting Blood Glucose[6]		25.3%	29.6%	31.6%	0.117

* p-values for continuous variables and categorical variables are from oneway ANOVA and chi-square, respectively; **(1)** μ ± SD; **(2)** Smoked at least 100 cigarettes in lifetime; **(3)** Average number of alcohol drinks consumed per week, **(4)** Number of moderate or vigourous activites performed in the past 30 days; **(5)** Waist-to-Height Ratio = waist circumference (cm) / height (cm); **(6)** Metabolic Syndrome Components for women: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<50 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥88 cm); **(7)** Obese Body Mass Index (BMI) ≥ 30

4.2 Correlation Between Central Obesity Indicators & Metabolic Syndrome Components

The degree of linear correlation between ICO and four metabolic syndrome components was assessed in males and females. The results of the correlation analysis between ICO and metabolic syndrome components, stratified by race/ethnicity and adjusted for age, are shown in Table 9 (males) and Table 10 (females). Raised blood pressure and raised fasting blood glucose were positively correlated with ICO among all three races/ethnicities, but not significant in Hispanic subjects ($p>0.05$). Raised triglycerides and reduced HDL were positively associated with ICO and significant in all three racial/ethnic groups ($p <.05$). In males, an ICO in whites, blacks, and Hispanics had a higher degree of correlation with raised triglycerides, raised blood pressure, and reduced HDL, respectively. The ICO of obese white, black, and Hispanic females had a higher degree of correlation with raised triglycerides, reduced HDL, and raised triglycerides, in that order.

Table 9. Correlation with ICO[1] and Metabolic Syndrome Components[2], Age-Adjusted, Obese Male Study Population, NHANES 2005-2006

Metabolic Syndrome Components	White (n = 524)	Black (n = 187)	Hispanic (n = 460)
Raised Blood Pressure[2]	.196**	.214**	.052
Raised Fasting Blood Glucose[2]	.147**	.143**	.089
Raised Triglycerides[2]	.251**	.183**	.234**
Reduced HDL[2]	.172**	.127**	.253**

Significance of association was measured using a two-tailed, partial correlation while controlling for age.

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

(1) Index of Central Obesity for men = waist circumference cutoff / average national height ≥ 0.58

(2) Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥102 cm)

Table 10. Correlation with ICO[1] and Metabolic Syndrome Components[2], Age-Adjusted, Obese Female Study Population, NHANES 2005-2006

Metabolic Syndrome Components	White (n = 722)	Black (n = 362)	Hispanic (n = 225)
Raised Blood Pressure[2]	.180**	.115*	.015
Raised Fasting Blood Glucose[2]	.196**	.123**	.059
Raised Triglycerides[2]	.352**	.138**	.246**
Reduced HDL[2]	.213**	.169**	.140*

Significance of association was measured using a two-tailed, partial correlation while controlling for age.

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

(1) Index of Central Obesity for women = waist circumference cutoff / average national height ≥ 0.54

(2) Metabolic Syndrome Components for women: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<50 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥88 cm)

Further evaluation of ICO's relationship with the four metabolic syndrome components was conducted to determine if age influenced the correlation. The results of the correlation analyses, stratified by racial/ethnic groups and age groups (20-39, 40-59, 60+), are reported in Table 11 (males) and Table 12 (females). As shown, the majority of associations between ICO and metabolic syndrome was positive and significantly correlated ($p < 0.05$), and most prevalent in obese white subjects and least frequent in obese Hispanics across race/ethnic and age groups.

Among whites, blacks, and Hispanics, the degree of correlation between ICO and each metabolic syndrome component varied with respect to age. No discernable patterns of association with increasing age were apparent across the racial/ethnic groups with respect to statistical significance or strength of correlation. Overall, no specific trend was observed between ICO and metabolic syndrome components with respect to advancing age.

Table 11. Age-Specific Correlation with ICO[1] and Metabolic Syndrome Components[2], Obese Male Study Population, NHANES 2005-2006

	Age 20 - 39			Age 40 - 59			Age 60+		
Metabolic Syndrome Components	White (n = 314)	Black (n = 164)	Hispanic (n = 91)	White (n = 340)	Black (n = 148)	Hispanic (n = 70)	White (n = 424)	Black (n = 148)	Hispanic (n = 78)
Raised Blood Pressure[2]	.212**	.220**	.164	.242**	.146	-.057	.151**	.291**	.051
Raised Fasting Blood Glucose[2]	.078	.195*	.194	.231**	.043	.033	.082	.203*	.029
Raised Triglycerides[2]	.293**	.121	.313**	.232**	.299**	.051	.230**	.126	.374**
Reduced HDL[2]	.226**	.073	.178	.161**	.097	.332**	.133**	.203*	.328**

Signficance of bivariate correlation was measured using Spearmans Rho.

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

(1) Index of Central Obesity for men = waist circumference cutoff / average national height ≥ 0.58

(2) Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis), obese waist circumference (≥102 cm)

Table 12. Age-Specific Correlation with ICO[1] and Metabolic Syndrome Components[2], Obese Female Study Population, NHANES 2005-2006

	Age 20 - 39			Age 40 - 59			Age 60+		
Metabolic Syndrome Components	White (n = 408)	Black (n = 195)	Hispanic (n = 136)	White (n = 332)	Black (n = 180)	Hispanic (n = 88)	White (n = 380)	Black (n = 128)	Hispanic (n = 72)
Raised Blood Pressure[2]	.078	.122	-.045	.274**	.231**	.124	.147**	-.040	.000
Raised Fasting Blood Glucose[2]	.148**	.165*	.045	.210**	.087	.007	.219**	.071	.249*
Raised Triglycerides[2]	.430**	.175*	.259**	.324**	.211*	.325**	.282**	-.020	.130
Reduced HDL[2]	.132**	.194**	.198*	.323**	.131	.155	.194**	.200*	-.006

Signficance of bivariate correlation was measured using Spearmans Rho.
** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
(1) Index of Central Obesity for women = waist circumference cutoff / average national height $\geq$ 0.54

4.3 Univariate Analysis Between Central Obesity Indicators & Metabolic Syndrome Components

Binary logistic regression was performed to quantify the association of ICO and WC obesity with metabolic syndrome components. Stratified by race/ethnicity, the odds of centrally obesity and raised blood pressure, raised fasting glucose, raised triglycerides, or reduced HDL are shown in Table 13 and Table 14 for males and females respectively. Both WC and ICO were associated with increased odds of each metabolic syndrome component. The odds ratios were not statistically significant in Hispanic females' ICO status and high blood pressure or between Hispanic males' WC and high blood pressure and raised blood glucose. All other odds ratios were statistically significant.

In Table 13 and Table 14, the odds ratios varied between central obesity indices with metabolic syndrome components. In males, the majority of metabolic syndrome components had a stronger association with ICO compared to WC, but not statistically significant. A much stronger associations were observed in Hispanic males with all four metabolic syndrome components, black males with hypertension or reduced HDL, and

white males with hypertension compared to a WC ≥102cm. As for the females, both WC and ICO had similar association with the metabolic syndrome components.

Although not statistically different, white subjects had the highest odds with the majority of metabolic syndrome components. ICO parameters were associated with highest odds for raised blood pressure and raised fasting blood glucose in the white males while Hispanic males had the highest odds for raised triglycerides and reduced HDL. White males with WC ≥102cm were the most likely to have raised blood pressure, raised fasting blood glucose, and raised triglycerides among the races/ethnicities. White females with an ICO ≥0.54 or a WC ≥88cm had the highest odds of having any of the four metabolic syndrome components compared to blacks and Hispanics.

Table 13. Univariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3], Male Study Population by Race, NHANES 2005-2006

		Metabolic Syndrome Components							
		Raised Blood Pressure		Raised Fasting Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Male ICO ≥ 0.58	Whites *(n = 524)*	3.2	(2.5 - 4.0)	2.4	(1.8 - 3.1)	2.6	(2.0 - 3.4)	2.0	(1.5 - 2.6)
	Blacks *(n = 187)*	2.8	(1.9 - 4.2)	2.2	(1.4 - 3.2)	2.4	(1.5 - 3.8)	2.0	(1.1 - 3.5)
	Hispanics *(n = 118)*	1.8	(1.0 - 3.1)	1.7	(1.0 - 2.9)	2.9	(1.7 - 5.0)	3.2	(1.8 - 5.9)
	Total *(n = 829)*	2.7	(2.2 - 3.3)	2.2	(1.8 - 2.7)	2.6	(2.2 - 3.2)	2.2	(1.7 - 2.8)
Male WC ≥ 102cm	Whites *(n = 538)*	2.8	(2.2 - 3.5)	2.5	(1.9 - 3.2)	2.6	(2.0 - 3.3)	2.3	(1.7 - 3.0)
	Blacks *(n = 199)*	2.5	(1.7 - 3.6)	2.2	(1.5 - 3.4)	2.4	(1.5 - 3.8)	1.9	(1.0 - 3.3)
	Hispanics *(n = 101)*	1.4	(0.8 - 2.4)	1.5	(0.9 - 2.6)	2.5	(1.5 - 4.4)	2.3	(1.3 - 4.1)
	Total *(n = 838)*	2.4	(2.0 - 2.9)	2.2	(1.8 - 2.7)	2.5	(2.0 - 3.0)	2.2	(1.7 - 2.8)

OR and 95% CI were calculated using binary logistic regression; **(1)** ICO for men = waist circumference cutoff / average national height ≥ 0.58; **(2)** Obese WC for men ≥ 102cm; **(3)** Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis)

Table 14. Univariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3], Female Study Population by Race, NHANES 2005-2006

		Metabolic Syndrome Components							
		Raised Blood Pressure		Raised Fasting Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Female ICO ≥ 0.54	Whites *(n = 722)*	3.1	(2.3 - 4.1)	4.7	(3.1 - 7.1)	5.9	(4.3 - 8.1)	3.2	(2.3 - 4.5)
	Blacks *(n = 362)*	2.6	(1.7 - 4.0)	2.4	(1.4 - 4.0)	3.2	(1.6 - 6.4)	2.7	(1.5 - 4.8)
	Hispanics *(n = 225)*	1.7	(0.9 - 3.4)	2.1	(1.1 - 4.0)	4.3	(2.2 - 8.5)	2.3	(1.2 - 4.3)
	Total *(n = 1309)*	2.7	(2.2 - 3.4)	3.4	(2.6 - 4.6)	4.6	(3.6 - 6.0)	2.9	(2.3 - 3.9)
Female WC ≥ 88cm	Whites *(n = 711)*	2.9	(2.2 - 3.9)	4.9	(3.2 - 7.5)	5.7	(4.2 - 7.8)	3.0	(2.2 - 4.3)
	Blacks *(n = 368)*	2.7	(1.8 - 4.2)	2.2	(1.3 - 3.7)	2.1	(1.1 - 4.0)	3.0	(1.6 - 5.6)
	Hispanics *(n = 206)*	1.6	(0.9 - 2.9)	2.3	(1.2 - 4.2)	4.9	(2.6 - 9.1)	2.9	(1.6 - 5.4)
	Total *(n = 1285)*	2.7	(2.2 - 3.3)	3.4	(2.6 - 4.6)	4.3	(3.3 - 5.5)	3.0	(2.3 - 3.9)

OR and 95% CI were calculated using binary logistic regression; **(1)** ICO for women = waist circumference cutoff / average national height ≥ 0.54; **(2)** Obese WC for women ≥ 88cm; **(3)** Metabolic Syndrome Components for women: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<50 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis)

Additional analysis was conducted to determine if trends in age influenced the association of central obesity with metabolic syndrome components. Stratified by the three age groups (20-39, 40-59, 60+), binary logistic regression calculated the odds of being ICO or WC obese with raised blood pressure, raised fasting glucose, raised triglycerides, or reduced HDL, which are shown in Table 15 (males) and Table 16 (females). All odds ratios were statistically different between obese and non-obese subjects across all age groups.

The strength of association with central obesity and metabolic syndrome components differed across age and gender. The association tended to be higher in the youngest subjects, 20-39 years of age, in both WC and ICO categories. In males, ICO demonstrated higher odds in the majority of metabolic syndrome components, which may indicate a better parameter for metabolic syndrome in males. However, in the female

analysis, the WC appeared to be a stronger risk factor for metabolic syndrome components than ICO in the majority of strata.

Table 15. Univariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3], Male Study Population by Age Group, NHANES 2005-2006

		Metabolic Syndrome Components							
		Raised Blood Pressure		Raised Fasting Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Male ICO ≥ 0.58	Age 20 - 39 *(n = 178)*	2.7	1.8 - 4.1	2.2	1.4 - 3.6	2.8	1.9 - 4.1	2.3	1.5 - 3.4
	Age 40 - 59 *(n = 266)*	2.0	1.4 - 2.8	1.9	1.3 - 2.7	2.6	1.8 - 3.6	2.4	1.6 - 3.7
	Age 60+ *(n = 385)*	2.0	1.4 - 2.7	1.5	1.1 - 2.1	2.8	2.0 - 3.9	2.9	1.8 - 4.6
	Total *(n = 829)*	2.7	(2.2 - 3.3)	2.2	(1.8 - 2.7)	2.6	(2.2 - 3.2)	2.2	(1.7 - 2.8)
Male WC ≥ 102cm	Age 20 - 39 *(n = 189)*	2.4	1.6 - 3.7	2.3	1.4 - 3.7	2.8	1.9 - 4.1	2.5	1.7 - 3.8
	Age 40 - 59 *(n = 274)*	2.0	1.4 - 2.8	1.7	1.2 - 2.5	2.4	1.7 - 3.3	2.4	1.6 - 3.7
	Age 60+ *(n = 375)*	1.7	1.2 - 2.4	1.7	1.3 - 2.4	2.4	1.7 - 3.3	2.4	1.5 - 3.7
	Total *(n = 838)*	2.4	(2.0 - 2.9)	2.2	(1.8 - 2.7)	2.5	(2.0 - 3.0)	2.2	(1.7 - 2.8)

OR and 95% CI were calculated using binary logistic regression; **(1)** ICO for men = waist circumference cutoff / average national height ≥ 0.58; **(2)** Obese WC for men ≥ 102cm; **(3)** Metabolic Syndrome Components for men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis)

Table 16. Univariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3], Female Study Population by Age Group, NHANES 2005-2006

		Metabolic Syndrome Components							
		Raised Blood Pressure		Raised Fasting Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Female ICO ≥ 0.54	Age 20 - 39 *(n = 448)*	2.2	1.0 - 4.7	4.0	1.8 - 8.5	5.7	3.7 - 8.7	2.3	1.6 - 3.4
	Age 40 - 59 *(n = 407)*	3.1	2.1 - 4.5	2.4	1.5 - 3.8	4.7	2.9 - 7.6	4.1	2.6 - 6.6
	Age 60+ *(n = 454)*	1.7	1.1 - 2.7	3.1	1.9 - 5.0	3.0	1.9 - 4.8	3.6	1.8 - 6.9
	Total *(n = 1309)*	2.7	(2.2 - 3.4)	3.4	(2.6 - 4.6)	4.6	(3.6 - 6.0)	2.9	(2.3 - 3.9)
Female WC ≥ 88cm	Age 20 - 39 *(n = 448)*	2.2	1.0 - 4.7	5.6	2.3 - 13.2	6.5	4.2 - 10.1	2.3	1.5 - 3.4
	Age 40 - 59 *(n = 409)*	4.2	2.8 - 6.2	2.5	1.6 - 4.0	4.1	2.6 - 6.5	3.8	2.4 - 6.1
	Age 60+ *(n = 428)*	1.9	1.3 - 2.9	3.2	2.0 - 5.0	2.5	1.7 - 3.8	3.9	2.1 - 7.1
	Total *(n = 1285)*	2.7	(2.2 - 3.3)	3.4	(2.6 - 4.6)	4.3	(3.3 - 5.5)	3.0	(2.3 - 3.9)

OR and 95% CI were calculated using binary logistic regression; **(1)** ICO for women = waist circumference cutoff / average national height ≥ 0.54; **(2)** Obese WC for women ≥ 88cm; **(3)** Metabolic Syndrome Components for women: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (<50 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis)

4.4 Multivariate Analysis Between Central Obesity Indicators & Metabolic Syndrome Components

To obtain a more accurate estimate of the true association of central obesity with metabolic syndrome components, multivariate regression was conducted. These analyses took into account several predictive variables simultaneously which controlled for age, education level, income level, health insurance status, smoking history, alcohol use, physical activity, and family history. The likelihood of being ICO or WC obese with each metabolic syndrome component was stratified by white, black, and Hispanic subjects and reported in Table 17, Table 18, and Table 19 respectively.

Shown in all three tables, most of the independent variables were not statistically significant among the races/ethnicities in both genders. Regarding race/ethnicity, the obese white subjects had elevated risks for each metabolic syndrome component ($p<0.05$), the obese black subjects had elevated risks for each metabolic syndrome

component but not consistently significant, and the obese Hispanic subjects had elevated and reduced risks for metabolic syndrome components but not statistically significant in all cases. With respect to gender, females with a WC $\geq$88cm tended to have higher odds with metabolic syndrome components than females with an ICO $\geq$0.54, with exception to the blacks' glucose and triglyceride levels. Males with an ICO $\geq$0.58 consistently had higher odds of having raised blood pressure compared to males with a WC $\geq$102cm. However, the odds of raised blood glucose, raised triglycerides, and reduced HDL varied between ICO and WC among the white, black, and Hispanic obese males. Overall, central obesity based on WC classification was associated with higher odds in twice as many strata compared to ICO.

Table 17. Multivariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3] in the White Study Population, NHANES 2005-2006

		Metabolic Syndrome Components of White Males								Metabolic Syndrome Components of White Females							
		Raised Blood Pressure		Raised Blood Glucose		Raised Triglycerides		Reduced HDL		Raised Blood Pressure		Raised Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
ICO		3.11	(2.12-4.56)	1.86	(1.25-2.75)	3.02	(2.07-4.41)	2.29	(1.47-3.57)	2.28	(1.34-3.87)	3.54	(1.75-7.19)	5.87	(3.73-9.24)	3.12	(1.87-5.22)
Age (years)		1.04	(1.03-1.05)	1.03	(1.02-1.04)	0.99	(0.98-1.00)	0.97	(0.96-0.99)	1.10	(1.08-1.12)	1.04	(1.03-1.06)	1.00	(0.99-1.01)	0.99	(0.98-1.00)
Education:	*< high school*	1.26	(0.67-2.37)	1.97	(1.09-3.56)	0.77	(0.41-1.43)	1.14	(0.56-2.32)	1.98	(0.78-5.02)	1.79	(0.71-4.55)	0.81	(0.38-1.71)	1.61	(0.72-3.59)
	high school	1.14	(0.72-1.80)	1.15	(0.72-1.83)	1.30	(0.86-2.03)	1.70	(1.05-2.77)	1.47	(0.85-2.54)	2.08	(1.14-3.81)	0.73	(0.45-1.16)	1.17	(0.70-1.96)
	> high school	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Income:	*<$20K*	1.61	(0.83-3.12)	1.07	(0.55-2.09)	1.48	(0.80-2.73)	1.95	(0.98-3.86)	0.67	(0.29-1.56)	0.58	(0.24-1.41)	2.10	(1.06-4.14)	1.54	(0.74-3.18)
	$20K-$44,999	1.32	(0.79-2.23)	1.10	(0.65-1.87)	1.00	(0.62-1.62)	1.08	(0.61-1.91)	0.83	(0.43-1.60)	0.53	(0.25-1.12)	1.45	(0.87-2.41)	0.81	(0.44-1.47)
	$45K-$74,999	1.71	(1.06-2.75)	1.25	(0.76-2.06)	1.36	(0.87-2.14)	0.97	(0.57-1.66)	0.93	(0.51-1.70)	0.53	(0.26-1.06)	1.47	(0.91-2.37)	1.13	(0.66-1.93)
	≥ $75K	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health Insurance? *Yes*		1.78	(0.95-3.33)	0.91	(0.49-1.70)	0.96	(0.56-1.64)	1.87	(0.98-3.56)	0.95	(0.41-2.21)	1.01	(0.36-2.86)	1.07	(0.55-2.10)	0.52	(0.27-1.01)
Cigarette Smoker[4]? *Yes*		1.03	(0.70-1.52)	0.96	(0.64-1.44)	0.81	(0.56-1.17)	0.85	(0.56-1.30)	0.84	(0.52-1.44)	1.37	(0.80-2.35)	1.15	(0.78-1.70)	1.19	(0.77-1.85)
Alcohol Use[5]		1.02	(1.0-1.04)	1.02	(1.00-1.03)	1.01	(1.00-1.03)	0.94	(0.90-0.97)	1.01	(0.96-1.07)	1.03	(0.96-1.10)	0.98	(0.93-1.03)	0.94	(0.87-1.01)
Physical Activity[6]		1.00	(0.99-1.01)	1.00	(0.99-1.01)	1.00	(0.98-1.01)	0.99	(0.97-1.01)	1.00	(0.99-1.02)	0.99	(0.97-1.01)	0.99	(0.97-1.00)	0.99	(0.98-1.01)
Family History[7]? yes		0.98	(0.66-1.44)	1.66	(1.12-2.45)	0.36	(0.83-1.7)	1.39	(0.91-2.13)	1.82	(1.13-2.93)	2.06	(1.21-3.53)	1.03	(0.71-1.51)	1.36	(0.89-2.08)
WC		2.46	(1.69-3.56)	2.06	(1.40-3.05)	2.56	(1.77-3.70)	2.40	(1.55-3.71)	3.40	(1.96-5.89)	4.03	(2.00-8.11)	7.39	(4.63-11.80)	3.22	(1.93-5.36)
Age (years)		1.04	(1.03-1.06)	1.03	(1.01-1.04)	1.00	(0.98-1.00)	0.97	(0.96-0.99)	1.10	(1.08-1.12)	1.05	(1.03-1.06)	1.00	(0.99-1.01)	0.99	(0.98-1.00)
Education:	*< high school*	1.32	(0.71-2.46)	2.00	(1.11-3.61)	0.80	(0.43-1.46)	1.13	(0.55-2.30)	2.00	(0.80-5.03)	1.94	(0.77-4.89)	0.85	(0.40-1.82)	1.70	(0.76-3.78)
	high school	1.23	(0.79-1.93)	1.19	(0.75-1.90)	1.41	(0.93-2.16)	1.78	(1.10-2.90)	1.37	(0.78-2.39)	2.00	(1.09-3.67)	0.68	(0.42-1.09)	1.16	(0.70-1.93)
	> high school	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Income:	*<$20K*	1.59	(0.83-3.06)	1.08	(0.55-2.11)	1.47	(0.80-2.70)	1.95	(0.98-3.87)	0.62	(0.27-1.45)	0.57	(0.23-1.38)	2.09	(1.04-4.19)	1.53	(0.74-3.16)
	$20K-$44,999	1.34	(0.80-2.23)	1.12	(0.66-1.90)	1.02	(0.63-1.64)	1.06	(0.60-1.89)	0.71	(0.36-1.39)	0.47	(0.22-1.00)	1.29	(0.77-2.17)	0.77	(0.42-1.40)
	$45K-$74,999	1.63	(1.02-2.61)	1.22	(0.74-2.01)	1.31	(0.84-2.05)	0.96	(0.56-1.65)	0.87	(0.47-1.59)	0.49	(0.24-1.01)	1.36	(0.83-2.21)	1.09	(0.63-1.86)
	≥ $75K	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health Insurance? *Yes*		1.77	(0.95-2.93)	0.92	(0.49-1.70)	0.97	(0.57-1.64)	1.84	(0.97-3.48)	0.88	(0.37-2.09)	1.02	(0.36-2.89)	1.08	(0.54-2.13)	0.53	(0.27-1.03)
Cigarette Smoker[4]? *Yes*		1.03	(0.70-1.51)	0.97	(0.65-1.46)	0.81	(0.56-1.16)	0.86	(0.56-1.32)	0.89	(0.55-1.44)	1.47	(0.86-2.52)	1.24	(0.83-1.85)	1.24	(0.80-1.93)
Alcohol Use[5]		1.02	(1.00-1.04)	1.01	(1.00-1.03)	1.01	(1.00-1.03)	0.94	(0.90-0.97)	1.02	(0.96-1.09)	1.03	(0.96-1.10)	0.99	(0.93-1.04)	0.94	(0.87-1.01)
Physical Activity[6]		1.00	(0.99-1.01)	1.00	(0.99-1.01)	1.00	(0.99-1.01)	0.99	(0.98-1.01)	1.01	(0.99-1.02)	0.99	(0.97-1.01)	0.99	(0.97-1.00)	1.00	(0.98-1.01)
Family History[7]? yes		1.07	(0.74-1.57)	1.68	(1.14-2.48)	1.29	(0.90-1.83)	1.44	(0.95-2.19)	1.73	(1.07-2.80)	1.99	(1.16-3.42)	1.01	(0.69-1.48)	1.35	(0.88-2.06)

OR and 95% CI was calculated for Metabolic Syndrome Components using binary logistic regression while controlling for age, education, income, insurance, smoking status, alcohol use, and physical activity; **(1)** ICO for women = ≥ 0.54, ICO for men = > 0.58; **(2)** Obese WC for women ≥ 88cm, Obese WC for men ≥ 102cm; **(3)** Metabolic Syndrome Components men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (women <50 mg/dl, men <40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis); **(4)** Smoked at least 100 cigarettes in lifetime; **(5)** Average number of alcohol drinks consumed per week, **(6)** Number of moderate or vigourous activites performed in the past 30 days, **(7)** Family history of diabetes or heart attack in close biological family member.

Table 18. Multivariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3] in the Black Study Population, NHANES 2005-2006

		Metabolic Syndrome Components of Black Males								Metabolic Syndrome Components of Black Females							
		Raised Blood Pressure		Raised Blood Glucose		Raised Triglycerides		Reduced HDL		Raised Blood Pressure		Raised Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
ICO		3.39	(1.75-6.57)	1.77	(0.95-3.31)	2.04	(1.05-3.96)	1.17	(0.44-3.06)	2.07	(0.90-4.77)	2.55	(1.02-6.38)	1.85	(0.62-5.54)	2.80	(1.04-7.54)
Age (years)		1.08	(1.05-1.11)	1.05	(1.03-1.08)	1.01	(0.98-1.03)	0.97	(0.93-1.00)	1.12	(1.08-1.16)	1.06	(1.04-1.09)	1.01	(0.98-1.03)	0.98	(0.95-1.00)
Education:	*< high school*	1.58	(0.59-4.25)	0.54	(0.20-1.49)	0.94	(0.33-2.69)	3.41	(0.81-14.32)	0.23	(0.06-0.87)	1.19	(0.41-3.49)	0.43	(0.11-1.73)	0.89	(0.28-2.79)
	high school	0.71	(0.34-1.48)	0.90	(0.45-1.83)	1.54	(0.73-3.24)	2.99	(0.98-9.11)	0.71	(0.25-2.04)	2.12	(0.79-5.68)	0.30	(0.06-1.51)	1.20	(0.43-3.36)
	> high school	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Income:	*<$20K*	0.58	(0.20-1.70)	1.65	(0.60-4.53)	0.62	(0.21-1.85)	0.54	(0.11-2.61)	3.10	(0.93-10.35)	0.41	(0.12-1.39)	2.10	(0.45-9.78)	2.92	(0.68-12.52)
	$20K-$44,999	0.61	(0.25-1.50)	0.69	(0.29-1.63)	0.72	(0.30-1.76)	0.94	(0.29-3.09)	2.95	(0.99-8.79)	0.59	(0.20-1.73)	1.73	(0.39-7.58)	3.03	(0.75-12.32)
	$45K-$74,999	1.00	(0.42-2.37)	1.04	(0.45-2.43)	0.57	(0.22-1.45)	0.39	(0.09-1.64)	0.81	(0.27-2.41)	0.25	(0.07-0.87)	1.59	(0.35-7.32)	2.32	(0.55-9.85)
	≥ $75K	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health Insurance? *Yes*		1.25	(0.56-2.77)	1.16	(0.50-2.72)	0.55	(0.24-1.27)	2.57	(0.66-10.02)	0.97	(0.34-2.74)	0.51	(0.19-1.41)	1.21	(0.34-4.36)	1.56	(0.54-4.54)
Cigarette Smoker[4]? *Yes*		0.82	(0.41-1.66)	0.61	(0.31-1.20)	1.24	(0.61-2.53)	1.90	(0.68-5.34)	0.95	(0.39-2.30)	1.07	(0.48-2.40)	1.53	(0.59-3.99)	1.30	(0.54-3.16)
Alcohol Use[5]		1.01	(0.98-1.04)	1.02	(0.98-1.05)	1.00	(0.96-1.04)	0.89	(0.77-1.02)	1.03	(0.94-1.13)	1.06	(0.96-1.18)	1.05	(0.97-1.14)	1.02	(0.95-1.11)
Physical Activity[6]		1.01	(0.99-1.03)	0.99	(0.97-1.02)	0.99	(0.96-1.01)	0.98	(0.94-1.02)	0.99	0.96-1.01)	1.01	(0.99-1.04)	1.01	(0.99-1.04)	1.01	(0.99-1.04)
Family History[7]? yes		1.09	(0.57-2.06)	1.34	(0.72-2.50)	0.75	(0.39-1.45)	0.97	(0.38-2.45)	1.14	(0.52-2.49)	4.53	(1.80-11.35)	1.92	(0.69-5.28)	2.46	(1.02-5.93)
WC		2.62	(1.62-5.87)	1.76	(0.95-3.25)	2.04	(1.05-3.93)	1.47	(0.58-3.74)	2.62	(1.09-6.31)	1.96	(0.80-4.77)	1.43	(0.48-4.26)	4.36	(1.39-13.72)
Age (years)		1.08	(1.05-1.11)	1.06	(1.03-1.08)	1.01	(0.99-1.03)	0.97	(0.93-1.00)	1.12	(1.08-1.16)	1.06	(1.03-1.09)	1.01	(0.98-1.04)	0.97	(0.95-1.00)
Education:	*< high school*	1.54	(0.57-4.18)	0.51	(0.19-1.42)	0.90	(0.32-2.57)	3.35	(0.80-14.06)	0.25	(0.07-0.92)	1.26	(0.43-3.68)	0.44	(0.11-1.79)	1.00	(0.32-3.13)
	high school	0.74	(0.35-1.53)	0.91	(0.45-1.85)	1.58	(0.75-3.31)	2.97	(0.98-8.97)	0.74	(0.26-2.12)	2.08	(0.78-5.52)	0.30	(0.06-1.52)	1.26	(0.44-3.59)
	> high school	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Income:	*<$20K*	0.62	(0.21-1.82)	1.73	(0.63-4.77)	0.67	(0.22-1.98)	0.51	(0.12-2.76)	2.99	(0.89-10.05)	0.45	(0.14-1.49)	2.17	(0.46-10.11)	2.68	(0.62-11.63)
	$20K-$44,999	0.66	(0.27-1.60)	0.71	(0.30-1.69)	0.76	(0.31-1.84)	0.96	(0.29-3.14)	2.81	(0.94-8.46)	0.62	(0.21-1.80)	1.76	(0.40-7.81)	2.67	(0.65-10.98)
	$45K-$74,999	1.04	(0.44-2.44)	1.06	(0.46-2.48)	0.58	(0.23-1.50)	0.39	(0.09-1.65)	0.78	(0.26-2.34)	0.28	(0.08-0.93)	1.66	(0.36-7.64)	2.13	(0.50-9.16)
	≥ $75K	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health Insurance? *Yes*		1.25	(0.57-2.77)	1.16	(0.50-2.72)	0.55	(0.24-1.28)	2.46	(0.64-9.52)	0.98	(0.34-2.80)	0.51	(0.19-1.39)	1.14	(0.32-4.02)	1.46	(0.51-4.19)
Cigarette Smoker[4]? *Yes*		0.85	(0.43-1.72)	0.61	(0.31-1.21)	1.27	(0.62-2.60)	1.90	(0.68-5.29)	0.96	(0.39-2.34)	1.12	(0.50-2.48)	1.54	(0.59-4.02)	1.38	(0.57-3.36)
Alcohol Use[5]		1.01	(0.98-1.04)	1.02	(0.98-1.05)	1.00	(0.96-1.04)	0.89	(0.77-1.03)	1.02	(0.93-1.11)	1.04	(0.95-1.14)	1.05	(0.97-1.13)	1.01	(0.94-1.09)
Physical Activity[6]		1.01	(0.99-1.03)	0.99	(0.97-1.02)	0.99	(0.96-1.01)	0.98	(0.94-1.02)	0.99	(0.96-1.02)	1.01	(0.99-1.02)	1.01	(0.99-1.04)	1.01	(0.99-1.04)
Family History[7]? yes		1.11	(0.59-2.10)	1.36	(0.73-2.54)	0.76	(0.40-1.47)	0.97	(0.38-2.46)	1.18	(0.54-2.60)	4.48	(1.80-11.18)	1.94	(0.70-5.35)	2.64	(1.08-6.42)

OR and 95% CI was calculated for Metabolic Syndrome Components using binary logistic regression while controlling for age, education, income, insurance, smoking status, alcohol use, and physical activity; **(1)** ICO for women = ≥ 0.54, ICO for men = > 0.58; **(2)** Obese WC for women ≥ 88cm, Obese WC for men ≥ 102cm; **(3)** Metabolic Syndrome Components men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (women <50 mg/dl, men <40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis); **(4)** Smoked at least 100 cigarettes in lifetime; **(5)** Average number of alcohol drinks consumed per week, **(6)** Number of moderate or vigourous activites performed in the past 30 days, **(7)** Family history of diabetes or heart attack in close biological family member.

Table 19. Multivariate Association of ICO[1] and WC[2] with Metabolic Syndrome Components[3] in the Hispanic Study Population, NHANES 2005-2006

		Metabolic Syndrome Components of Hispanic Males								Metabolic Syndrome Components of Hispanic Females							
		Raised Blood Pressure		Raised Blood Glucose		Raised Triglycerides		Reduced HDL		Raised Blood Pressure		Raised Blood Glucose		Raised Triglycerides		Reduced HDL	
		OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
ICO		1.23	(0.37-4.08)	1.19	(0.46-3.05)	3.99	(1.54-10.32)	2.03	(0.77-5.35)	0.57	(0.15-2.13)	1.04	(0.95-3.10)	4.86	(1.42-16.69)	1.74	(0.63-4.81)
Age (years)		1.11	(1.06-1.16)	1.03	(1.00-1.07)	1.03	(0.99-1.06)	0.99	(0.96-1.02)	1.13	(1.08-1.19)	1.07	(1.03-1.10)	1.01	(0.98-1.04)	1.00	(0.97-1.03)
Education:	*< high school*	2.78	(0.62-12.47)	0.19	(0.04-0.88)	0.46	(0.12-1.75)	1.60	(0.43-5.97)	0.99	(0.21-4.64)	1.33	(0.38-4.57)	3.47	(1.17-10.29)	3.66	(1.25-10.67)
	high school	1.09	(0.19-6.12)	1.81	(0.44-7.48)	0.43	(0.11-1.71)	1.15	(0.27-4.96)	1.96	(0.49-7.94)	0.86	(0.26-2.78)	1.79	(0.64-5.03)	1.81	(0.66-5.00)
	> high school	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Income:	*<$20K*	5.95	(0.69-51.57)	1.30	(0.24-7.16)	0.20	(0.03-1.23)	1.81	(0.39-8.48)	0.21	(0.03-1.24)	0.36	(0.09-1.43)	1.31	(0.36-4.82)	0.24	(0.06-0.91)
	$20K-$44,999	1.69	(0.39-7.43)	2.38	(0.69-8.28)	3.05	(0.87-10.76)	0.46	(0.12-1.78)	0.23	(0.04-1.30)	0.11	(0.03-0.47)	0.88	(0.26-3.00)	0.42	(0.13-1.38)
	$45K-$74,999	0.76	(0.17-3.53)	0.93	(0.26-3.35)	1.65	(0.50-5.48)	1.05	(0.32-3.50)	0.05	(0.01-0.44)	0.31	(0.08-1.16)	0.73	(0.22-2.50)	0.45	(0.14-1.46)
	≥ $75K	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health Insurance? *Yes*		1.94	(0.32-11.87)	16.94	(1.78-161.3)	2.03	(0.56-7.35)	2.67	(0.61-11.70)	0.09	(0.02-0.43)	0.62	(0.18-2.07)	1.03	(0.35-3.02)	0.26	(0.09-0.73)
Cigarette Smoker[4]? *Yes*		1.84	(0.51-6.58)	2.17	(0.77-6.10)	1.20	(0.44-3.27)	0.51	(0.18-1.39)	0.79	(0.22-2.84)	0.29	(0.10-0.85)	2.74	(1.12-6.70)	2.15	(0.88-5.25)
Alcohol Use[5]		1.00	(0.93-1.08)	0.93	(0.86-1.01)	1.00	(0.92-1.08)	0.94	(0.85-1.05)	1.29	(1.01-1.65)	1.19	(0.98-1.43)	0.79	(0.59-1.05)	0.85	(0.68-1.08)
Physical Activity[6]		0.98	(0.94-1.02)	1.00	(0.99-1.02)	0.99	(0.96-1.01)	1.00	(0.99-1.02)	1.02	(0.96-1.07)	0.98	(0.94-1.03)	1.00	(0.96-1.04)	1.02	(0.99-1.06)
Family History[7]? yes		0.72	(0.21-2.42)	1.81	(0.67-4.92)	0.61	(0.23-1.57)	1.01	(0.39-2.63)	1.48	(0.42-5.23)	0.98	(0.39-2.47)	0.78	(0.34-1.81)	1.01	(0.44-2.30)
WC		1.19	(0.38-3.70)	1.56	(0.61-3.94)	4.79	(1.75-13.09)	1.97	(0.77-5.03)	0.98	(0.29-3.30)	1.81	(0.65-5.00)	10.54	(3.00-36.95)	2.66	(1.03-6.89)
Age (years)		1.11	(1.06-1.16)	1.03	(0.99-1.06)	1.03	(0.99-1.06)	0.99	(0.96-1.02)	1.13	(1.07-1.18)	1.07	(1.03-1.10)	1.02	(0.99-1.04)	1.00	(0.98-1.03)
Education:	*< high school*	2.86	(0.65-12.60)	0.19	(0.04-0.89)	0.50	(0.13-1.93)	1.73	(0.47-6.39)	0.98	(0.21-4.53)	1.26	(0.37-4.34)	3.45	(1.11-10.71)	3.60	(1.22-10.63)
	high school	1.15	(0.21-6.26)	1.89	(0.47-7.68)	0.60	(0.16-2.34)	1.37	(0.32-5.84)	1.91	(0.47-7.72)	0.82	(0.25-2.67)	1.83	(0.62-5.46)	1.78	(0.64-4.98)
	> high school	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Income:	*<$20K*	5.83	(0.69-49.56)	1.29	(0.23-7.17)	0.19	(0.03-1.12)	1.71	(0.37-7.91)	0.22	(0.04-1.30)	0.37	(0.09-1.50)	1.81	(0.44-7.53)	0.25	(0.06-0.96)
	$20K-$44,999	1.70	(0.39-7.48)	2.39	(0.69-8.33)	3.55	(0.97-12.97)	0.48	(0.12-1.87)	0.22	(0.04-1.21)	0.10	(0.02-0.42)	0.80	(0.23-2.82)	0.39	(0.12-1.29)
	$45K-$74,999	0.78	(0.17-3.57)	0.92	(0.25-3.35)	1.84	(0.54-6.23)	1.10	(0.33-3.68)	0.06	(0.01-0.46)	0.29	(0.08-1.10)	0.72	(0.20-2.60)	0.44	(0.13-1.45)
	≥ $75K	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref	ref
Health Insurance? *Yes*		1.98	(0.32-12.11)	16.57	(1.77-155.1)	2.34	(0.65-8.50)	2.96	(0.68-12.90)	0.09	(0.02-0.46)	0.63	(0.18-2.12)	1.06	(0.34-3.30)	0.25	(0.09-0.72)
Cigarette Smoker[4]? *Yes*		1.84	(0.52-6.58)	2.23	(0.79-6.32)	1.30	(0.47-3.54)	0.51	(0.18-1.40)	0.76	(0.21-2.73)	0.27	(0.09-0.81)	2.64	(1.03-6.74)	2.09	(0.84-5.17)
Alcohol Use[5]		1.00	(0.93-1.08)	0.94	(0.86-1.02)	1.01	(0.93-1.09)	0.95	(0.86-1.05)	1.28	(1.00-1.63)	1.18	(0.98-1.42)	0.78	(0.59-1.04)	0.86	(0.68-1.07)
Physical Activity[6]		0.98	(0.94-1.02)	1.00	(0.99-1.02)	1.00	(0.97-1.01)	1.00	(0.99-1.02)	1.02	(0.96-1.07)	0.98	(0.94-1.03	1.00	(0.92-1.05)	1.03	(0.99-1.06)
Family History[7]? yes		0.71	(0.21-2.40)	1.88	(0.69-5.13)	0.65	(0.25-1.71)	1.01	(0.39-2.61)	1.38	(0.40-4.80)	0.99	(0.39-2.50)	0.75	(0.31-1.80)	0.98	(0.43-2.26)

OR and 95% CI was calculated for Metabolic Syndrome Components using binary logistic regression while controlling for age, education, income, insurance, smoking status, alcohol use, and physical activity; **(1)** ICO for women = ≥ 0.54, ICO for men = > 0.58; **(2)** Obese WC for women ≥ 88cm, Obese WC for men ≥ 102cm; **(3)** Metabolic Syndrome Components men: raised blood pressure (≥135 systolic, ≥85 diastolic, or taking meds), raised triglycerides (≥150mg/dl), reduced HDL (women <50 mg/dl, men <40 mg/dl), raised fasting blood glucose (≥100 mg/dl or Type II diabetes diagnosis); **(4)** Smoked at least 100 cigarettes in lifetime; **(5)** Average number of alcohol drinks consumed per week, **(6)** Number of moderate or vigourous activites performed in the past 30 days, **(7)** Family history of diabetes or heart attack in close biological family member.

CHAPTER V
DISCUSSION AND CONCLUSION

5.1 Discussion

Based on our results, we failed to reject the null hypothesis and were unable to support ICO as a better parameter for metabolic syndrome diagnosis compared to WC among white, black, and Hispanic adults in the United States. Our findings included: (1) subjects with ICO or obese WC had elevated risks of raised blood pressure, raised blood glucose, raised triglycerides, and reduced HDL, (2) the association between ICO and each metabolic syndrome component was not significantly different from WC, (3) the odds of having raised blood pressure, raised blood glucose, raised triglycerides, or reduced HDL was not consistently higher in either ICO or WC and varied between race/ethnicity and gender, (4) the correlation and association of central obesity and metabolic syndrome components was found statistically significant more often in white subjects compared to black and Hispanic subjects, and (5) prevalence of ICO increased as age increased, but age did not influence the correlation and association of ICO with metabolic syndrome components.

Differences of demographic factors, behavioral factors, and medical history were observed in the study subpopulations, with a focus centered on the racial/ethnic and gender disparities regarding anthropometric measurements and risk for metabolic syndrome components. Prevalence of obesity among the racial/ethnic groups depended on the anthropometric parameter used. Our analysis indicated 33% of men and 37 % of

women from our study population were considered obese with a BMI ≥30. When stratified by race/ethnicity, disparities in the prevalence of obese BMI measurements were found in the females but not in the males. Approximately 54% of black women and 41% of Hispanic women were obese compared to 32% of white women. These results were very similar to the 2003-2004 prevalence of obesity in the United States reported by the Centers for Disease Control and Prevention (CDC).[66] However, when our study population was measured for central obesity by WC and WHtR parameters, the prevalence within the groups increased, but the gap between the groups decreased considerably among the black, Hispanic, and white females (73%, 70%, 64% and 72%, 76%, 65% respectively). While WC identified a larger proportion of centrally obese in white and black males and females, Hispanics had the highest prevalence of central obesity based on ICO. When stratified by ICO status, Hispanic subjects with an ICO were more likely to have coexisting normal WC measurements compared to whites and blacks.

Other notable racial/ethnic and gender differences were observed with respect to height measurements, waist circumference measurements, and clinical measurements. Comparing genders, women had higher rates of obesity based on all anthropometric measurements: BMI, WC, and ICO. However, the females had lower rates of metabolic syndrome components (hypertension, elevated triglycerides, and elevated fasting blood glucose), with exception to the higher rates of reduced HDL levels in black and white obese females. The lower rates may be contributable to the protective influence of gynoid adiposity on insulin resistance, which is common in the female phenotype.[7, 12, 14, 61] When stratified by ICO status, obese females and obese males had very similar WHtR averages ranging from 0.64 to 0.66. This may indicated that a WHtR is a closer

agreement of parameters between genders and may adjust for sexual dimorphism. Having a single WHtR value to measure central obesity in either gender is a plausible concept.

Comparing race/ethnicity, Hispanics tended to be shorter than whites and blacks, larger in girth than whites, and had higher rates of ICO than whites and blacks. A larger proportion of Hispanics was affected by raised triglycerides, reduced HDL, and raised fasting blood glucose compared to whites and blacks, although glucose levels were not statistically different. The ICO appears to be encompassing the adjustment for the smaller stature in the Hispanic population. Further analysis of univariate and multivariate binary logistic regression indicated racial/ethnic inequalities with respect to the association of ICO and WC parameters with metabolic syndrome components. During univariate analysis, white subjects (particularly males) with an ICO presented higher risks for metabolic syndrome components compared to WC. When age, education, income, health insurance status, smoking status, alcohol use, physical activity, and family history were controlled for, ICO and WC remained a statistical significant indicator in the white subjects, but less significant in the black and Hispanics. These results may be a reflection of the ICO parameters derived from previous studies and national averages, which is heavily dominated by the white race. The United States adult population is comprised of approximately 76% Caucasians.[67] Ethnic-specific ICO cut-points may be needed for the diverse groups in the United States.

5.2 Limitations

This study does present some limitations. Restrictions existed due to the study design and the nature of secondary data. First, the cross-sectional design does not allow

for temporality and direction of risk factors and health outcomes. From this design, it is indeterminable if central obesity occurred before or after metabolic syndrome components developed. Second, the secondary data obtained from NHANES 2005-2006 did not provide sufficient information to satisfy IDF's definition of metabolic syndrome components. For example, NHANES inquires "are you taking prescribed medication for high cholesterol" but does not prompt the subject for the type of cholesterol being treated.[68] Cholesterol-reducing medications include the following categories: (1) statins lower LDL and modestly lower triglycerides and raise HDL, (2) selective cholesterol absorption inhibitors lower LDL and modestly lower triglycerides and raise HDL, (3) resins lower LDL, (4) fibrates lower triglycerides and sometime increase HDL, and (5) niacin lowers triglycerides and LDL and raises HDL.[69] Since it is undetermined what cholesterols are being affected, subjects who reported they were taking cholesterol medication in conjunction with normal triglyceride and HDL levels were omitted as having elevated triglycerides or reduced HDL. This may have underestimated the prevalence of hyperlipidemia and distorted the correlation and association. Case in point, the prevalence of male subjects with elevated triglyceride levels potentially could have increased from 39.4% to 47.2% if subjects taking cholesterol medication were included. And the third limitation in our study design hinders the application of our findings to the general public. These results can not be generalized to the entire United States population because our delimitations excluded subjects under the age 20 and races/ethnicities other than white, black, or Hispanic.

Another limitation was in the definition of WC parameters. IDF defines central obesity using gender and ethnic-specific WC cut-points. They acknowledge that these

are pragmatic cut-points and that further research is required for risk assessment. Even so, guidelines for IDF WC cut-points for the white, black, and Hispanic populations in the United States are unclear. IDF recommends: (1) United States citizens of Europid origin should use both European [≥94cm for men, ≥80cm for women) and North American [≥102cm for men, ≥88cm for women] cut-points during epidemiological studies, but comments that NCEP ATP-III cut-points will be used in clinical settings, (2) Sub-Saharan Africans should use European data until more specific data are available, (3) Arab populations should use European data until more specific data are available, and (4) ethnic South and Central Americans should use South Asian recommendations [≥90cm for men, ≥80cm for women] until more specific data are available. When referring to European data, it was uncertain if the black Americans of Sub-Saharan and Arab descent should use Europid cut-points or use North American cut-points. Also Hispanics were confined to ethnic South and Central Americans. Based on the ambiguity and the emphasis on current clinical practices in the United States, NCEP ATPIII WC cut-points were used for white, black, and Hispanic adults study population. Ethnic-specific cut-points for WC and ICO for this study population may have produced different results.

5.3 Recommendations for Future Research

First, future research should conduct longitudinal studies to determine which WHtR value is most effective for screening central obesity and predicting metabolic syndrome in white, black, and Hispanic adults of the United States. Previous studies conducted ROC analysis to determine the WHtR value most sensitive to metabolic syndrome components. Researchers may want to design similar studies to determine if

other WHtR cut-points are better indicators of metabolic syndrome than the ICO parameters used in this study. Second, researchers may want to analyze for spurious affects with respect to the correlation of WHtR with metabolic syndrome components, as suggested by Molarius and Seidall.[70] They indicate that short stature has been associated with increased morbidity and may create a false correlation between WHtR and health events. Studies should address this issue and test for validity. And lastly, public health experts should evaluate the different parameters of central obesity and determine which is the most sensitive for detecting metabolic syndrome. A single definition of metabolic syndrome needs to be created to best capture the risk of this disorder across all populations.

5.4 Conclusion

Central obesity is a risk factor that can lead to insulin resistance and metabolic syndrome. Those with metabolic syndrome have significantly higher risks for developing diabetes or CVD. Public health experts estimate that billions of dollars in medical expenditures and indirect costs are spent managing patients with diabetes and CVD each year in the United States. Morbidity and mortality stemming from central obesity has reached epidemic proportions. Implementing a central obesity parameter that can accurately capture those at risk of developing metabolic syndrome is crucial.

Although this study failed to support the hypothesis that ICO was a better parameter for metabolic syndrome for the white, black, and Hispanic American adults, ICO should be considered a robust measurement for estimating central obesity and metabolic syndrome risk in addition to WC. ICO was found to be highly correlated and exposed adults to elevated risks for hypertension, dyslipidemia, and insulin resistance.

Future studies may discover a more sensitive ICO cut-point value that identifies a larger portion of individuals at elevated risks for metabolic syndrome. Nonetheless, a universal definition of metabolic syndrome is pertinent to improve screening and surveillance of central obesity across all populations.

REFERENCES

1. Mathur R. Metabolic Syndrome. MedicineNet.com. Available at: http://www.medicinenet.com/metabolic_syndrome/article.htm. Accessed May, 2008.
2. Després J, Lemieux, I, Prud'homme, D. Treatment of obesity: need to focus on high risk abdominally obese patients. British Medical Journal. 2001;322:716–720.
3. Vague J. The Degree of Masculine Differentiation of Obesities: A Factor Determining Predisposition To Diabetes , Athersclerosis, Gout, And Uric Calculous Disease. The Maerican Journal of Clinical Nutrition. 1956;4:20-34.
4. History of Metabolic Syndrome. The Metabolic Syndrome Institute. Available at: http://www.metabolic-syndrome-institute.org/informations/history/index.php. Accessed June, 2008.
5. Reaven GM. Banting Lecture 1988. Role of insulin resistance in human disease. [Abstract]. Diabetes 1988;37.
6. Reaven GM. Role of Insulin Resistance in Human Disease (Syndrome X): An Expanded Definition. Annual Review of Medicine. 1993;44:121-131.
7. Després JP NA, Tremblay A, Ferland M, Moorjani S, Lupien PJ, Thériault G, Pinault S, Bouchard C. Role of deep abdominal fat in the association between regional adipose tissue distribution and glucose tolerance in obese women. Diabetes. 1989;38:304-309.
8. Fujioka S, Matsuzawa Y, Tokunaga K, Tarui S. Contribution of intra-abdominal fat accumulation to the impairment of glucose and lipid metabolism in human obesity. Metabolism. 1987;36:54-59.
9. Deen D. Metabolic Syndrome: Time for Action. American Family Physician. 2004;69:2875-2882,2887-2878.
10. Grundy SM. Metabolic Syndrome: A Growing Clinical Challenge. Medscape Cardiology. Available at: http://www.medscape.com/viewarticle/484166_1. Accessed June 2008.
11. Grundy SM. Metabolic Syndrome: Connecting and Reconciling Cardiovascular and Diabetes Worlds. 2006;47:1093-1100.
12. Bergman RN, Kim SP, Catalano KJ, et al. Why Visceral Fat is Bad: Mechanisms of the Metabolic Syndrome. Obesity. 2006;14:16S-19S.
13. Arner P. Insulin resistance in type 2 diabetes: role of fatty acids. Diabetes Metab Res Rev. . 2002;18:S5-S9.
14. Heymsfield S. Human Body Composition: Human Kinetics; 2005.
15. Bjorntorp P. Metabolic implications of body fat distribution. Diabetes Care. 1991;14:1132-1143.
16. Snijder MB, Visser M, Dekker JM, Seidell JC. RE: "Changes In Body Weight And Body Fat Distribution As Risk Factors For Clinical Diabetes In US Men". Am. J. Epidemiol. 2004;160:1133-1134.

17. Alberti KGMM, Zimmet, P. Z. W. H. O. Consultation. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus. Provisional report of a WHO Consultation. Diabetic Medicine. 1998;15:539-553.

18. Executive Summary of the Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III). JAMA. 2001;285:2486-2497.

19. IDF Worldwide Definition of the Metabolic Syndrome. International Diabetes Federation. Available at: http://www.idf.org/home/index.cfm?node=1429. Accessed May, 2008.

20. Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults: findings from the third National Health and Nutrition Examination Survey. JAMA. 2002;287:356-359.

21. Smith SC. Multiple risk factors for cardiovascular disease and diabetes mellitus. The American journal of medicine. 2007;120:S11.

22. Dunstan D, Zimmet P, Welborn T, et al. The rising prevalence of diabetes and impaired glucose tolerance: the Australian Diabetes, Obesity and Lifestyle Study. Diabetes care. 2002;25:829-834.

23. Isomaa B, Almgren P, Tuomi T, et al. Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes care. 2001;24:683-689.

24. Economic Costs of Diabetes in the U.S. in 2007. Diabetes Care. Vol 31: American Diabetes Association; 2008:1-20.

25. Complications of Diabetes in the United States. American Diabetes Association. Available at: http://www.diabetes.org/diabetes-statistics/complications.jsp. Accessed June 2008.

26. Heart Disease and Stroke 2008 Update At-a-Glance Statistics. American Heart Association. Available at: http://www.americanheart.org/downloadable/heart/1200078608862HS_Stats%202008.final.pdf. Accessed June 2008.

27. Body Fat Analyzing - Comparing Methods for Measuring Body Fat. Available at: http://www.new-fitness.com/body_fat_analyzing.html. Accessed June 2008.

28. Bray G, Bouchard, C. Handbook of Obesity: Informa Health Care; 2004.

29. Ellis KJ. Selected body composition methods can be used in field studies. Journal of Nutrition, The. 2001;131:1589-1595S.

30. Okosun I, Choi S, Boltri J, et al. Trends of Abdominal Adiposity in White, Black, and Mexican-American Adults, 1988 to 2000. Obesity Research. 2003;11:1010-1017.

31. Lee K, Song YM, Sung J. Which obesity indicators are better predictors of metabolic risk?: healthy twin study. Obesity. 2008;16:834-840.

32. Schneider HJ, Glaesmer H, Klotsche J, et al. Accuracy of Anthropometric Indicators of Obesity to Predict Cardiovascular Risk. J. Clin. Endocrinol. Metab. . 2007;92:589-594.

33. Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome;a new world-wide definition. A Consensus Statement from the International Diabetes Federation. Diabetic Medicine. 2006;23:469-480.
34. Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. International Journal of Food Sciences and Nutrition. 2005;56:303-307.
35. Hsieh SD, Muto T. The superiority of waist-to-height ratio as an anthropometric index to evaluate clustering of coronary risk factors among non-obese men and women. Preventive Medicine. 2005;40:216-220.
36. Hsieh SD, Muto T. Metabolic syndrome in Japanese men and women with special reference to the anthropometric criteria for the assessment of obesity: Proposal to use the waist-to-height ratio. Preventive Medicine. 2006;42:135-139.
37. Parikh RM, Joshi SR, Menon PS, Shah NS. Index of central obesity - A novel parameter. Medical Hypotheses. 2007;68:1272-1275.
38. Kahn R, Buse J, Ferrannini E, Stern M. The Metabolic Syndrome: Time for a Critical Appraisal: Joint statement from the American Diabetes Association and the European Association for the Study of Diabetes. Diabetes Care. 2005;28:2289-2304.
39. Stolar M. Metabolic syndrome: controversial but useful. Cleveland Clinic journal of medicine. 2007;74:199-202, 205.
40. Snijder MB, Dekker JM, Visser M, et al. Larger Thigh and Hip Circumferences Are Associated with Better Glucose Tolerance: The Hoorn Study. Obesity. 2003;11:104-111.
41. Zhu S, Heymsfield SB, Toyoshima H, Wang Z, Pietrobelli A, Heshka S. Race-ethnicity-specific waist circumference cutoffs for identifying cardiovascular disease risk factors. The American journal of clinical nutrition. 2005;81:409-415.
42. Wells JCK, Cole TJ, Bruner D, Treleaven P. Body shape in American and British adults: between-country and inter-ethnic comparisons. International journal of obesity. 2008;32:152-159.
43. Després JP, Couillard C, Gagnon J, et al. Race, visceral adipose tissue, plasma lipids, and lipoprotein lipase activity in men and women: the Health, Risk Factors, Exercise Training, and Genetics (HERITAGE) family study. Arteriosclerosis, thrombosis, and vascular biology. 2000;20:1932-1938.
44. Carroll JF, Chiapa AL, Rodriquez M, et al. Visceral fat, waist circumference, and BMI: impact of race/ethnicity. Obesity. 2008;16:600-607.
45. Lovejoy JC, de la Bretonne JA, Klemperer M, Tulley R. Abdominal fat distribution and metabolic risk factors: effects of race. Metabolism, clinical and experimental. 1996;45:1119-1124.
46. Perry AC, Applegate EB, Jackson ML, et al. Racial differences in visceral adipose tissue but not anthropometric markers of health-related variables. Journal of applied physiology. 2000;89:636-643.

47. Kanaley JA, Giannopoulou I, Tillapaugh-Fay G, Nappi JS, Ploutz-Snyder LL. Racial differences in subcutaneous and visceral fat distribution in postmenopausal black and white women. Metabolism, clinical and experimental. 2003;52:186-191.

48. Conway JM, Yanovski SZ, Avila NA, Hubbard VS. Visceral adipose tissue differences in black and white women. The American journal of clinical nutrition. 1995;61:765-771.

49. Albu JB, Murphy L, Frager DH, Johnson JA, Pi-Sunyer FX. Visceral fat and race-dependent health risks in obese nondiabetic premenopausal women. Diabetes. 1997;46:456-462.

50. Hsieh SD, Yoshinaga H, Muto T. Waist-to-height ratio, a simple and practical index for assessing central fat distribution and metabolic risk in Japanese men and women. Int J Obes Relat Metab Disord.27:610-616.

51. Ashwell M, Cole T, Dixon A. Ratio of waist circumference to height is strong predictor of intra-abdominal fat. BMJ. 1996;313:559-560.

52. Aekplakorn W, Pakpeankitwatana V, Lee CM, et al. Abdominal obesity and coronary heart disease in Thai men. Obesity. 2007;15:1036-1042.

53. Wu HY, Chen LL, Zheng J, Liao YF, Zhou M. Simple anthropometric indices in relation to cardiovascular risk factors in Chinese type 2 diabetic patients. The Chinese journal of physiology. 2007;50:135-142.

54. Kuczmarski RJ, Flegal KM. Criteria for definition of overweight in transition: background and recommendations for the United States. Am J Clin Nutr. 2000;72:1074-1081.

55. Clinical Guidelines On The Identification, Evaluation, And Treatment Of Overweight And Obesity In Adults: Evidence Report. in: National Heart L, and Blood Institute, ed: National Institute of Health; 1998:1-262.

56. Gracey M, Burke V, Martin DD, Johnston RJ, Jones T, Davis EA. Assessment of risks of "lifestyle" diseases including cardiovascular disease and type 2 diabetes by anthropometry in remote Australian Aborigines. Asia Pacific journal of clinical nutrition. 2007;16:688-697.

57. Chehrei A, Sadrnia S, Keshteli AH, Daneshmand MA, Rezaei J. Correlation of dyslipidemia with waist to height ratio, waist circumference, and body mass index in Iranian adults. Asia Pacific journal of clinical nutrition. 2007;16:248-253.

58. Tarastchuk JC, Guérios EE, Bueno RR, et al. Obesity and coronary intervention: should we continue to use Body Mass Index as a risk factor? Arquivos brasileiros de cardiologia. 2008;90:284-289.

59. Lorenzo C, Serrano-Ríos M, Martínez-Larrad MT, et al. Which obesity index best explains prevalence differences in type 2 diabetes mellitus? Obesity. 2007;15:1294-1301.

60. Smith SC, Haslam D. Abdominal obesity, waist circumference and cardio-metabolic risk: awareness among primary care physicians, the general population and patients at risk--the Shape of the Nations survey. Current medical research and opinion. 2007;23:29-47.

61. Diaz VA, Mainous AG, Baker R, Carnemolla M, Majeed A. How does ethnicity affect the association between obesity and diabetes? Diabetic medicine. 2007;24:1199-1204.
62. Kopelman P. Obesity as a medical problem. Nature. 2000;404:635-643.
63. Khan A, Haq FU, Pervez MB, et al. Anthropometric correlates of blood pressure in normotensive Pakistani subjects. International Journal of Cardiology. 2008;124:259-262.
64. Okosun IS, Boltri JM, Hepburn VA, Eriksen MP, Davis-Smith M. Regional fat localizations and racial/ethnic variations in odds of hypertension in at-risk American adults. Journal of human hypertension. 2006;20:362-371.
65. 2005-2006 National Health and Nutrition Examination Survey; Survey Operations Manuals, Brochures, Consent Documents. National Center for Health Statistics. Available at: www.cdc.gov/nchs/about/major/nhanes/nhanes2005-2006/nhanes05_06.htm. Accessed June, 2008.
66. Ogden C, Carroll M, McDowell M, Flegal KM. NCHS Data Brief: Obesity Among Adults in the United States - No Statistically Significant Change Shince 2003-2004. The Centers for Disease Control and Prevention. Available at: http://www.cdc.gov/nchs/data/databriefs/db01.pdf. Accessed June, 2008.
67. National Population Estimates - Characteristics: national Sex, Race, and Hispanic Origin. U.S Census Bureau. Available at: www.census.gov/popest/national/asrh/NC-EST2007/NC-EST2007-03.xls. Accessed June, 2008.
68. National Health and Nutirtion Examination Survey: 2005-2006 Questionnaire Survey. National Center for Health Statistics. Available at: http://www.cdc.gov/nchs/about/major/nhanes/nhanes2005-2006/quex05_06.htm. Accessed June, 2008.
69. Cholesterol-Lowering Drugs. The American Heart Association. Available at: http://www.americanheart.org/presenter.jhtml?identifier=163. Accessed June, 2008.
70. Molarius A, Seidell JC. Selection of anthropometric indicators for classification of abdominal fatness--a critical review. International journal of obesity. 1998;22:719-727.